HARVARD UNIVERSITY

LIBRARY

OF THE

Museum of Comparative Zoology

MEMOIRS

174 P
2-3

READ BEFORE THE

BOSTON SOCIETY OF NATURAL HISTORY;

BEING A NEW SERIES

OF THE

BOSTON JOURNAL OF NATURAL HISTORY.

VOLUME IV.

BOSTON:
PUBLISHED BY THE SOCIETY.
1886–1893.

PUBLISHING COMMITTEE.

ALPHEUS HYATT.
WILLIAM G. FARLOW.
CHARLES S. MINOT.
THOMAS A. WATSON.
SAMUEL HENSHAW.

CONTENTS OF VOLUME IV.

I. The significance of bone structure. Plates 1–3. *By Thomas Dwight, M. D.* (Published October, 1886.) 1

II. The development of the ostrich fern, Onoclea struthiopteris. Plates 4–7. *By Douglas Houghton Campbell, Ph.D.* (Published April, 1887.) 17

III. The introduction and spread of Pieris rapae in North America. 1860–1885. Plate 8. *By Samuel H. Scudder.* (Published September, 1887.) 53

IV. A study of North American Geraniaceae. Plates 9–12. *By William Trelease.* (Published January, 1888.) 71

V. The taconic of Georgia and the Report on the geology of Vermont. Plate 13. *By Jules Marcou.* (Published March, 1888.) 105

VI. The Entomophthoreae of the United States. Plates 14–21. *By Roland Thaxter.* (Published April, 1888.) 133

VII. The flora of the Kurile Islands. Plate 22. *By K. Miyabe.* (Published February, 1890.) 203

VIII. Phylogeny of the Pelecypoda; the Aviculidae and their allies. Plates 23–30. *By Robert Tracy Jackson.* (Published July, 1890.) 277

IX. New types of cockroaches from the carboniferous deposits of the United States. Plates 31–32. *By Samuel H. Scudder.* (Published September, 1890.) 101

X New carboniferous Myriapoda from Illinois. Plates 33–38. *By Samuel H. Scudder.* (Published September, 1890.) 117

XI. Illustrations of the carboniferous Arachnida of North America, of the orders Anthracomarti and Pedipalpi. Plates 39–40. *By Samuel H. Scudder.* (Published September, 1890.) 143

XII. The insects of the triassic beds at Fairplay, Colorado. Plates 41–42. *By Samuel H. Scudder.* (Published September, 1890.) 157

XIII Fusion of hands. Plates 43–44. *By Thomas Dwight, M.D., LL.D.* (Published August, 1892.) 173

XIV. A bibliography of vertebrate embryology. *By Charles Sedgwick Minot.* (Published October, 1893.) 187

Index 615

Errata 618

MEMOIRS

READ BEFORE THE BOSTON SOCIETY OF NATURAL HISTORY.

I. The Significance of Bone Structure.

By Thomas Dwight, M. D.

Parkman Professor of Anatomy at Harvard University.

Read March 3, 1886.

It is not easy to determine who first appreciated the fact that the spongy tissue of bone is not a meaningless tangle but an architectural structure. The late Professor Jeffries Wyman read a paper "On the Cancellated Structure of some of the Bones of the Human Body" before this Society on Nov. 7, 1849. He stated that there is a reference to the matter in Ward's "Outlines of Human Osteology," which was published in London in 1838. He, however, gave the credit of first calling attention to the subject to Bourgery and Jacob (1835). Professor Wyman wrote as follows: "The cancelli of such bones as assist in supporting the weight of the body are arranged either in the direction of that weight or in such a manner as to support and brace those cancelli which are in that direction. In a mechanical point of view, they may be regarded in nearly all these bones as a series of 'studs' and 'braces.'"[1] He thought that the arrangement in some of the human bones is characteristic and has a definite relation to the erect position. "As a rule the strength of the bone seems to be obtained in other mammals at the expense of its lightness by giving greater thickness and density to the outer shell, as well as by stouter cancelli with smaller areolæ." He found but slight traces of a corresponding plan in other animals; a conclusion that seems surprising on the part of so acute an observer.

Professor Humphry drew attention to the mechanical advantage gained by the arrangement of the cancelli in his treatise on the human skeleton published in 1858.

Professor Hermann v. Meyer[2] of Zurich announced this discovery anew in 1867 and is generally looked up to as the first to grasp the idea. He certainly deserves the credit of having studied it more thoroughly than any of his predecessors. He thought that the cancellated tissue could be divided into two types, that fitted to resist pressure in one direction, and that fitted to resist it in many. The discussion was taken up with great interest by German anatomists.

[1] Boston Journal of Natural History, Vol. VI.

[2] Reichert und DuBois Reymond's Archiv, 1867.

Dr. Julius Wolff[1] applied the principles of mathematics more rigidly than had been heretofore done to the study of the bony plates. At his request Professor Culmann caused to be drawn the stress lines of a crane of the general shape of the upper end of the femur and found a surprising resemblance between the stress lines and the trabeculae. Dr. Wolff concluded that from our knowledge of the needs of a bone we can predict its internal structure and also that the converse of the proposition is true. He writes: "And thus we come to the view which, when we have once grasped it, seems so natural and self-evident, that the plan on which the bone is built is the only possible one." I make no comment on these conclusions as the discussion of this and allied questions is the purpose of the present paper.

Wolfermann[2] wrote shortly after in the same sense and included in his observations the bones of many animals. Not content with admitting the relation between the mechanical needs of the bone and its structure, he went so far as to assert that the former are actually the cause of the latter.

Aeby[3] maintained that the arrangement of the laminae of a bone depends on its movements. The laminae, according to this theory, are parallel when the axes of two connected bones remain so, but if one of these bones is flexed on the other by turning on one axis, the plates converge in the planes perpendicular to the axis. If the bones move on more than one axis there is a general convergence. Moreover, all these types show near joints a system of slightly developed transverse plates. At points of muscular insertion the muscle represents the axis of a bone.

Merkel,[4] in a paper on the femur, expressed some doubt as to the teleological arrangement of the plates, basing his objection on the striking similarity of the plan in the human heel bone which rests on the ground and that of the quadruped which projects in the air.

Bardeleben[5] published a monograph on the spinal column in man and animals which he argued is to be regarded as a trestle-work.

Langerhans[6] and Wagstaffe[7] made many sections of human bones and each concurred in the prevailing view.

Ogston[8] started the theory that plates developed from articular cartilage are perpendicular to the surface of the bone, and those from the periosteum parallel to it.

Professor Humphry[9] contraverted this, maintaining that the arrangement is not due to development, but rather has "relation to the line of weight and the direction of the forces to be resisted."

In 1882, v. Meyer[10] classified more accurately than he had done the different kinds of cancellated tissue. He recognized a round-meshed structure fitted to resist pressure in all directions. This generally presents in the middle what he calls an intermediate spongy portion, made of thicker plates and larger spaces, which adds to the strength. Then there are the short bones that receive pressure in two opposed directions and con-

[1]Virchow's Archiv, Band L, 1870.
[2]Reichert und Du Bois Reymond's Archiv, 1872.
[3]Centralblatt für med. Wissensch., 1873.
[4]Virchow's Archiv, Band LIX, 1874.
[5]Beiträge zur Anatomie der Wirbelsaule, Jena, 1874.
[6]Virchow's Archiv, Band LXI, 1874.
[7]St. Thomas' Hospital Reports, 1875.
[8]Journal of Anat. and Phys., Vol. XII, 1878.
[9]Ditto, Vol. XIII, 1878.
[10]Beiträge zu Biologie. (Bischoff's Jubilaum.)

sequently have a system in the main longitudinal. Finally, there are the shafts of the long bones, the solid walls of which break up into plates near their ends. Moreover there are plates near the ends of bones which he thinks must be considered continuations of tendons.

Roux[1] of Breslau, in a paper in which he analyzes the internal structure of an anchylosed knee, makes a further classification which, though very good, is rather long to be given here especially as it is more minute than the purposes of this paper require.[2]

That the internal structure of bone shows a well-planned architecture suited to the mechanical requirements of the part is an axiom so generally accepted that we may take it as a starting-point, although, as will appear later, it requires considerable modification. There are, indeed, many aspects to the question, which is one of no common difficulty. Although some of the most thorough of the authors mentioned above have referred to the mechanical requirements in the widest sense, it seems that many, if not most, writers have looked upon bones merely as weight-bearing appliances. Considered in this light alone the question is not a simple one. Is the arrangement of the plates that requisite when the bone is in the position of the greatest strain? If not, it is clear that there must be what builders call a large factor of safety, that is, that much more material must be disposed along the stress lines than would otherwise be necessary. Another point not to be lost sight of is that, besides the actual weight a bone may have to bear, it must be able to resist compression against the next bone to which it is subjected by muscular action.

But if we look on bones as not merely adapted to weight-bearing but as serving also for the origin and insertion of muscles, do we find the plan of the bone modified for these requirements? There seems no possibility of doubting it. The femur of a quadruped inclines downward and forward. If we suppose the upper part to be made of the least amount of bone sufficient to bear the weight, it is clear that the shaft at the neck would be thicker from before backward than transversely, as the strain comes in the former direction. But the contrary occurs: the greatest breadth is transverse. Clearly then there are other factors than the purely static needs of the bone. If this shape be for the purpose of resisting any strain it must be that of the muscles. Although, as I shall undertake to show later, certain structures occur that are in no way teleological, it is hard to believe that so important a feature as this widening of the femur should be purposeless, and we are almost forced to hold that either it is to give greater surface for muscular origin and insertion, or that it is to resist lateral tension from muscular action, or that the two reasons coëxist.

The precise part played by muscles is extremely difficult to determine. With them it is proper to associate ligaments, there being no doubt that what is a ligament in some animals is a muscle in others and, moreover, it seems a matter of no consequence whether the strain is applied to a bone by the pull of a muscle on a tendon or less directly by making tense a ligament. There seems no doubt that a factor in the shape of bones, besides weight-bearing, is muscular attachment. Clearly a large muscle must have a

[1]Beiträge zur Morphologie der functionellen Anpassung. Archiv für Anat. und Entwick., 1885.

[2]It is not thought necessary to discuss what has been written on the growth of bone nor on the arrangement of the cancelli in pathological conditions.

sufficiently extended surface of origin, and again it is necessary for leverage that many muscles, at least, should be attached to projections. We find, therefore, that the whole shape of a bone is determined so as to meet other than the static requirements. As for processes like the trochanters no one denies that they serve for muscular attachment. I have elsewhere[1] published some notes on the structure of bone beneath processes for the insertion of muscles and ligaments. In some cases, notably when the process is very small, like the anterior inter-trochanteric ridge of the femur, the shaft is continued beneath a layer of cancellated tissue. When the process is larger the surface of the shaft seems to go round it rather than under it. The shaft is sometimes, but by no means usually, found continued under the tubercle of the human radius and the coronoid process of the ulna. It is sometimes represented by plates recalling the process which Bigelow[2] has named the "true neck of the femur" which, when very well developed, appears to represent the posterior wall of the neck continued beneath the lesser trochanter. As a rule, however, there is no well-marked separation of the cancellated tissue of any of the larger processes from that of the main bone beneath. The third trochanter of the horse (fig. 1) is a striking instance. One would be inclined to look for a continuation of the shaft beneath it to support the weight, but such is not the case.

It being then admitted that the shape of bones shows provision both for a sufficient extent of muscular origin and for tendinous insertions it remains to see what internal arrangement of the laminae is found in the processes. Of course in cases where what would be the shape of the bone, were static needs the only ones, has been modified to admit of a larger space for muscular origin, it follows that the internal structure must also of necessity be modified; but an important and difficult question is whether the internal structure shows any special arrangement to resist the pull of the muscles and whether any of the bony plates are continuous with tendinous or ligamentous insertions. I am strongly inclined from the study both of sections of dry bone, and of bones decalcified with the soft parts unremoved, to reply to both questions in the negative. Ligaments and tendons are, I believe, never inserted at right angles to the surface of a bone. They spread out over it, being inseparably united with the periosteum and in some cases with cartilages. Thus the strain is diffused over a larger surface. It is very remarkable to what thin surfaces and to what weakly supported ones powerful muscles are attached; familiar instances are the tuberosities of the humerus and the trochanters of the femur in man. The cancelli inside of these processes are light and seem arranged to support the delicate shell of bone and not to resist muscular action. In some few places, as for instance at the back and underside of the os calcis, there are series of plates that seem to represent fibres from the tendo Achillis and the plantar ligaments, but I have not been able to satisfy myself of any continuity in decalcified specimens. Be that as it may, such systems are exceptional.

To sum up to this point it appears that the shape of the bone depends not solely on its needs as an organ of support but also on its needs as a fixed point for the origin and insertion of muscles. Further, that although this modification in shape must necessarily demand a change of the internal architecture, yet this change is only what is requisite

[1] Remarks on the Position of the Femur and on its so-called "True Neck." Journal of Anatomy and Physiology, Vol. IX, 1875.

[2] The Hip (Philadelphia, Henry C. Lea) 1869; also The Boston Medical and Surgical Journal, 1875.

for the support of the bone under the changed conditions and that the strain of the muscles being diffused over its surface the internal structure shows no special adaptation to meet it. Finally, that, in some few cases, there are apparent exceptions to this last rule.

We have so far considered an individual bone as if it were simply a piece of a machine which, to fulfil its function, must have a certain size and shape and a certain power of resistance. Other and broader questions now present themselves.

We know that certain classes and orders of animals have a characteristic structure of bone of which the most striking instances are the slender bones of fishes and the expanded bones of birds. The same is true of certain orders of mammals; but we do not know just how far such characteristic structures can be ascribed to genera or to species. That these peculiarities are in general advantageous may be considered as accepted. but are they always so? Do they extend to every bone of the skeleton? Are useless or rudimentary structures found in bone? Do particular bones show a similarity to corresponding bones in other animals, and if so, is the structure in each case solely teleological? In fine is there ground for Wolff's assertion that a bone is built on the only possible plan?

It was the writer's intention originally to limit the discussion to mammalian bones, and this plan has been followed in the main, but he has been led in one or two instances to refer to those of other classes.

Let us now pass in review, the proximal ends of the humerus and femur of a number of mammals, beginning with man, and having compared the bones of the two extremities in the same species together, then compare each with the corresponding bones of other animals.

Man. These bones have been so often described, that a summary sketch shall suffice. In the humerus (fig. 2) the shaft is thin, the spongy tissue light and its plan very indistinct. It is denser in the head where it is of the round-meshed pattern. It is very light in the greater tuberosity. Sometimes a system of plates running up into the head from the inner side of the shaft can be made out. The femur (fig. 3) is of a much heavier make, the shaft is much thicker and the plan distinct. In brief, this consists of decussating plates from either side of the shaft, of a very well marked series, running from the lower side of the neck into the dense, round-meshed head, of a series of arches from the outer shaft which meet and perhaps pass through this series, and finally of the light tissue in the trochanter major with a few plates parallel to its surface. The important differences between the bones are the rudimentary neck of the humerus, its much lighter structure and indistinct plan. The teleological significance is evident.

Apes. The humerus of the *chimpanzee* (fig. 4) might easily be mistaken for a small human one, its chief difference being a greater density of structure. The femur (fig. 5) is on the same plan as in man. The tissue of the head is very dense. Its centre is almost solid bone. The bones are larger in the *gorilla*. The humerus (fig. 6) is a little broader and the series of plates running to the head from the inner side of the shaft is more defined. The femur (fig. 7) is very like the human one, but below the trochanter the shaft is convex. The head is very dense. In both these animals the femur is much denser and heavier than the humerus, though the difference is less than in man. It is hard to say whether the difference between the two is greater in the chimpanzee or the gorilla. In the *mandrill* the humerus (fig. 8) is broader, the plates from the shaft show

a decussation and the series from the inner side to the head is more distinct. In short, it is more like a femur. The bones of *monkeys* differ from those of man and the higher apes by their greater lightness. The cavity in the shaft is relatively larger and reaches nearer the ends.

Carnivora. I have examined the bones of the *dog*, *lion*, *otter* and *sea otter*. No detailed description is necessary. The humerus and femur are more alike than in man and the apes, the neck being relatively longer in the humerus and shorter in the femur than in the latter order. There is the same general plan in humerus and femur. The head of the latter shows a somewhat greater solidity than in the former. This difference was especially marked in the dog and hardly perceptible in the sea otter. This animal was chosen in order to ascertain whether the bones present any resemblance to those of the seal. Unfortunately, I could examine but a single sea otter and the bones proved immature and consequently unsatisfactory, for typical structure is usually evident only after the union of the epiphyses.

Pinnipedia. The bones of the *seal* are very interesting. The section of the humerus (fig. 9) passes through the head and the inner[1] tuberosity. It shows plates leaving both sides of the shaft and tending towards the middle. Others pass into the head from below. The line of the epiphysis of the head is well marked and probably the line obliquely cutting off the tuberosity marks the epiphysis also. The head is of a light, round-meshed structure. The greater part of the tuberosity is taken up by plates, radiating from two solid masses, situated, respectively, on the upper and outer border, which, meeting at its outer extremity, form with the attached base a triangle, inside of which is some light, spongy tissue. The femur (fig. 10) is by no means very different, but less distinct. It shows a head of no greater solidity than the humerus. In both bones we find a structure differing from any that we have yet seen, consisting of broad, relatively thick plates with large spaces between them, which appears to be a generic peculiarity. This description is made from bones of the *P. vitulina*, but the figure of the femur is taken from the *P. Groenlandica* which corresponds strikingly. The humerus in *Otaria jubata* shows a denser structure in the head and the characteristic structure of the seal is less evident, though there is an approach to it. As above stated, the bones of a young sea otter showed no trace of this peculiarity.

Cetacea. I have examined bones of small *whales* fifteen or eighteen feet long, probably the *Globicephalus melas*, and also of *porpoises*. The section (fig. 11) embraces the whole humerus. The denser, spongy tissue of the head is distinguishable. Plates from the thick inner side run into it, and then there is a beautifully marked decussation at the upper end of the bone of plates from either side. The highest ones from the outer side run to the top of the bone. The tuberosity is of lighter texture. The thickening of the solid parts on each side near the middle of the bone is even more marked in a similar section of a young porpoise. The structure is very dense, and consists of thin plates arranged very closely together. It seems characteristic.

Ungulata. I have examined bones of the *horse*, *moose*, *gazelle*, *caribou*, *sheep*, *goat* and *hartebeest* (an African antelope). The four first-mentioned species differ from the last-mentioned three in having the cancellated tissue prolonged much further into the

[1] This section through the inner tuberosity shows, I think, a greater resemblance to the rest of the series than one through the outer, owing probably to the curious formation of the humerus in this animal.

shaft of the bone. The *moose* (figs. 12 and 13) is a good example of the former type, and indeed it is an excellent specimen of the structure in the quadruped. The internal structure is as similar as the difference in shape between the humerus and femur allows. There is very little difference in density between the heads of these bones in the same animal. I have been able to cut only the femur of *Rangifer tarandus*, the caribou. The structure of the head is very dense, decidedly more so than in the femur of the *moose*. The plates in the neck are very delicate and near together, giving the bone rather a characteristic appearance. The bones of the *hartebeest* (figs. 14 and 15) are very striking. The walls of the shaft are very thin in proportion to its diameter, and there is no cancellated tissue below the very ends. This is pretty dense in the heads and lighter in the tuberosity and trochanter. A series of plates can be traced from the inner side of the shaft into the head. Both bones, but especially the humerus, present large plates and bars running through empty spaces, giving very much the appearance of a bird's bone. As it was known that this animal had died in a menageric, it seems possible that the bones are pathological, but both the *sheep* and the *goat* show in a less degree the thin shaft and the absence of cancellated tissue in parts where it is found in the other ungulata that I have examined.

Marsupialia. In the *kangaroo* the humerus is much smaller than the femur, and the plan not very clear. The femur (fig. 16) shows the usual plan; but these bones present one remarkable peculiarity. In the bones hitherto described the surface of the head is always of spongy tissue and the line of the epiphysis when visible cuts off a considerable portion of the head. In the femur of the kangaroo the line of the epiphysis separates a crust of solid bone covering the head. This crust seems precisely as compact as the bone of the shaft. In the humerus there is a similar arrangement, only the outer portion of the crust shows a number of small holes, an approach to spongy structure. Anxious to know if this is a marsupial peculiarity, I examined the bones of the *opossum* and found precisely the same hard cap constituted by the epiphysis in the femur, but in the humerus the epiphysis consists of spongy tissue.

To study the general plan of the heads of these bones we should begin with a quadruped. We find in the humerus and femur a system of plates passing off from the outer and inner walls of the shaft and forming Gothic arches at the top of the bone. The head is of dense, spongy tissue, of the round-meshed pattern, into which runs a series of plates from the underside of the neck. The great tuberosity and trochanter are made of looser tissue. In the former, the plan is less certain; in the latter, it is in the main, (as seen in frontal plane) a rectangular network of vertical and horizontal plates. Externally there may be a series parallel with the surface. In most of the animals mentioned, this general description will apply to both humerus and femur. The head of the humerus is of about the same consistency as that of the femur in ungulata, in which the weight is about equally distributed between the bones, and in the seal, in which neither bone bears any weight. In the carnivora, in which the anterior extremity is more prehensile, the head is lighter and this difference is still more evident in apes and man. In the apes we find a lengthening of the neck in the femur and a shortening of that of the humerus, with a corresponding change in the internal structure.

Reserving till later a discussion of several questions, we may make from this series of specimens at least the general conclusion that these homologous bones of the two extremities of the same animal correspond closely in structure when their function is nearly the same, and that when their function is different their structure differs also but that the main features of the common plan can still be recognized.

The study of the calcaneum and the olecranon is very instructive. A longitudinal section of the human heel bone (fig. 17) may be described as follows: There is a thickening, from which plates radiate, situated at the lower border of the upper articular surface. Some go forward to the plate that rests against the cuboid, others downward, others backward and downward, the latter being joined by other plates arising above the point mentioned. There is then a series of plates acting as ties passing from the posterior towards the anterior surface describing a curve with a downward convexity. These plates come very near to one another at the under surface of the bone. The whole structure may very aptly be compared to a triangular rafter even to the appearance of a vacant space in the middle at the neutral point. Besides these systems there is often seen a series of plates parallel to the posterior surface held to be continuous with the fibres of the tendon.

This structure is so admirably adapted to the upright position that it seems very surprising that a strikingly similar arrangement should be found in the os calcis of quadrupeds in which its position is utterly different, the hind end pointing upward in the air instead of resting on the ground. Merkel uses this as an argument against the teleological significance of the internal structure of bone, and it long seemed to me an almost insuperable difficulty; but in fact, rightly interpreted, it is a strong argument on the other side. Let us suppose a man in the act of running with one foot in the air and the whole weight of the body resting on the toes of the other. The heel is raised and the foot is in the position of a quadruped's. Most of the weight is, of course, transmitted through the leg to the os calcis and it may be divided into two components, one running forward to the cuboid, the other backward to the tuberosities of the bone. These no longer rest on the ground and the pressure conveyed to that end of the bone is resisted by the tense tendo Achillis, so that the conditions are essentially the same in running and in standing; only of course there is a far greater strain in the former position which is the one normal to quadrupeds.

The bone in the *chimpanzee* (fig. 18) is very like the human one but the series of plates that runs backward does not appear to reach the inferior surface of the bone.

In the plantigrade bear (fig. 19) the bone is relatively longer, but the principal new features it presents are the greater thickness of the upper and lower surfaces. In the lion (fig. 20), horse, deer and gazelle the bone is more elongated, but the same general description will apply to all. In the seal (fig. 21) the bone is not used to bear the weight of the animal but for purposes of propulsion in swimming. The contraction of the muscles presses it against the astragalus and the line of pressure divides as in the other animals. We find, therefore, an essentially similar plan of internal structure. The thick lower border is seen to be composed of many of the laminae of the inferior system which meet at this place. The structure of the bone is lighter than in most of the other animals mentioned, but the characters of the seal are less distinct than in the long bones or the vertebrae.

At first sight it would seem that in man there is little in common between the olecranon and the calcaneum. It is possible, however, to recognize in the very delicate spongy tissue of the human olecranon (fig. 22) two systems that pass upward crossing each other in a series of graceful curves. The best marked comes from the posterior border, the other from the articular surface of the great sigmoid cavity. In the *gorilla* we have the same thing only the scale is larger and the plates stronger. The plan is such as we find in many other prominences.

Now in the lion we have an example of the arrangement common in quadrupeds in which the olecranon, pointing upward just like the os calcis, has a strong tendon implanted at the extremity in the same way and transmits the weight to the shaft of the bone as the os calcis transmits it to the tarsus. The teleological relations are strikingly similar. The main difference is in the point last mentioned, that in the os calcis there is a series of plates running downward and forward against the surface for the cuboid and that in the ulna the pressure is transmitted through the shaft. In the *lion* (fig. 23), which may do for a type, there are found in the elongated olecranon, two series of plates crossing one another at the back strikingly resembling the calcaneum, and we find that the compact substance of the back of the shaft is formed by the aggregation of many distinct plates. In the *bear* the shape of the olecranon is peculiar. It is pointed and quite different from the rather human heel bone but the internal structure shows a decussation of plates. In some of the ungulata the shape as well as the internal structure is very similar. I think that in many cases it would be very difficult to tell whether a section, which one could not compare with others, were through the end of the olecranon or the end of the calcaneum.

This series shows, therefore, a similarity of structure coincident with similarity of function in non-homologous bones and the presence of the general plan throughout the series.

We shall next examine the vertebrae and more particularly their bodies. The essential features of the body of a mammalian vertebra are a series of longitudinal plates running from one end to the other and a series of weaker plates crossing them at right angles especially developed near the ends. The surfaces of the pedicles are almost always thick. They give off plates that in sagittal sections are sometimes seen joining the transverse system and in other places describing curves and joining the longitudinal. Sections parallel to the intervertebral discs show at times series of loops from the pedicles across the body decussating with similar ones from the opposite side.[1] These are probably formed in part by the cut edges of longitudinal plates. The chief system in all mammals is the longitudinal one.

In *man* (fig. 24) one is struck by the lightness of the whole structure. The plates are nearer together at the ends and wider apart at the centre, where they are thicker. This may serve for a centre of support and also form the walls of the vascular canals. Something may be seen of the oblique systems, but they seem too weak to be of much use.

The same general description may apply to the *lion* (fig. 25) and the *dog;* but the plates are nearer together and the formation is denser, there being little space in the middle. In the *horse* (fig. 26) again the essential system is a dense longitudinal one.

[1] The reader will find much that is interesting and valuable in Bardeleben's monograph on the spine already referred to.

The longitudinal arrangement is evident in the seal (fig. 27), but transverse sections of the lumbar vertebrae show the plates diverging from the compact bone on the inner side of the pedicle with remarkable clearness. There is also a set running horizontally inward from the lower surface of the transverse process which arises from the body of the vertebra. These vertebrae present another peculiarity: to wit, the great thickness of the epiphyses at the ends of the bodies which consist of cancellae arranged longitudinally. This description applies to the *Groenlandica* as well as to the *P. foetida*. In one or two dorsal vertebrae of the *Otaria*, which I had an opportunity to examine, the longitudinal system was clear and the transverse indistinct. In all these there were the thick plates and large spaces which are characteristic of the seal tribe.

The vertebrae of *cetaceans* show the characteristic structure of many thin plates very close together. The arrangement is clearly longitudinal with tubular spaces. In the dorsal region the structure is very dense and heavy, the middle of the body in a small whale being almost solid bone. The structure is lighter in the lumbar region and in the caudal lighter still. The systems of horizontal plates from the transverse processes can be traced but a short distance in the body. The lumbar vertebra of the whale (fig. 28) has one peculiarity that I have seen in neither carnivora nor ungulata, namely, a solid crust of bone surrounding the body. The upper one is continuous with the compact tissue of the pedicles, the lower with that of the transverse processes. In the dorsal region this solid shell is found only at the upper side of the vertebra bounding the canal. I have not found this in either the dorsal or lumbar region of the porpoise.

I have had the opportunity of cutting but one bone of the *Sirenia*, one of the anterior lumbo-caudal vertebrae of the manatee (fig. 29). The structure is very whale-like. It has the same plate surrounding the body as in the same region in *globicephalas;* the same decussation of the plates from the transverse process on each side; a *substantia intermedia* and at the lowest part a structure of coarser plates and larger spaces. Above this on either side of the middle the structure is denser than in the lumbar vertebra of the whale.

Summing up our observations on the bodies of the mammalian vertebrae we find that the plan is in the main a longitudinal one. In man, the structure is the lightest of all; in whales and the manatee the heaviest. There can hardly be a doubt that the pressure to which the bodies of the vertebrae are constantly subjected is in an antero-posterior direction being due to the compression they exercise one on another. In quadrupeds the dorso-lumbar region may be compared to a bridge,[1] one end of which is supported on piers (to wit, the femurs), the other being suspended (from the scapulae) sometimes only by muscles, sometimes having the additional support of a clavicle. The thorax is suspended by the serratus, the neck by the levator anguli scapulae and therefore the thoracic spine is supported through the ribs. The pieces of the spine are connected by strong longitudinal ligaments; many and powerful muscles, by their contraction, press the vertebrae together, hence the longitudinal arrangement of the plates, for it is necessary to the safety of the arch that it should be compressed. In man, the arrangement is different. The spine is placed on end and really requires less strength than in the quadruped.

[1] Compare Lucae; Robbe und Otter. Abhandlungen des Senckenb. naturf. Ges., Bd. VIII and IX.

In whales the conditions are not quite the same; nevertheless the spine is not straight but bent in the thoracic region. The shape of the bodies of the vertebrae is not such that this could be done without the restraining force of ligaments and the vast power of the muscles must pull the vertebrae together; hence, here also the longitudinal arrangement.

In the seal the plan is less modified. It has been stated that the pressure is transmitted to the thoracic portion of the spine through the ribs and very probably this occurs through the tubercle that articulates with the transverse process much more than through the head of the rib. Hence the pedicles connecting the transverse processes with the body must be strong. But this is not the only reason; the pedicles have also to transmit the strain, probably very considerable, occasioned by the pressure on the articular processes in various movements. Thus the firm walls which the pedicles usually present are what might be expected, and it is natural enough that plates should pass off from these points of support through the vertebral bodies both lengthwise and crosswise. Still, as a rule, the work done by these systems does not seem important. Before approaching some other questions, it may be interesting to take a cursory view of the vertebrae of other classes.

In the osseous fishes (fig. 30) the body is doubly concave. The end plates are supported by others running antero-posteriorly which appear as radiating lines in a transverse section. These are connected by occasional transverse plates which in some places are so developed as to suggest concentric rings.

In the alligator (fig. 31), the plan bears a certain resemblance to that of the fish. There is a general radiating arrangement with mostly large interspaces. Near the upper part of the body, *i. e.*, just below the canal, the structure is thicker. The cancellous tissue is very dense in the rounded end. Longitudinal sections show plates running from before backward and also near the side, strong plates running downward and backward from the anterior articular processes, and others downward and forward from the posterior ones. There is a beautiful strong system of plates with large interspaces in the arches and roots of the transverse processes that is very characteristic.

In the great Galapagos tortoise a cervical vertebra shows a plan of rather thick plates and large interspaces. The osseous tissue is much less dense than in the alligator. The vertebra cut being the only cervical one in the series, it is not worth while to discuss the arrangement in detail as it cannot well be compared with the others. Suffice it to say that the plates are disposed chiefly longitudinally, and that the general appearance is not in the least like that of the alligator.

The vertebra of the snake is curious, presenting more solid substance than any vertebra I am acquainted with. Figs. 33 and 34 represent two frontal sections made respectively near the back and front of the body of a vertebra of a pithon. Fig. 34 is just behind the hollowed anterior end. The circular portion of spongy tissue is just back of the cup and is inclosed by an envelope of compact bone. The latter is found also at the lowest part of the body and in the articular processes which receive the posterior ones of the vertebra in front. The other section shows almost exclusively solid tissue both in the body and in the posterior articular processes. Fig. 32 shows a horizontal section through the body. The spongy tissue on the convex head is well shown; that in

the cup is seen better at another level. We see here the section of a median vertical plate extending from the cup of compact tissue at the front, back to the head where it breaks up into trabeculae. There is a band of spongy tissue running from the articular surface for the head of the rib obliquely backward and inward. It may be that elasticity is gained by the constituent parts of the ball and socket joint at the ends of the bone being made of spongy tissue, which transmits the pressure to deeper solid bone. The articular processes that fit into one another are remarkably solid while the articular tubercle for the head of the rib is cancellated. Fig. 35, showing a frontal section of a dorsal vertebra of a bald eagle, makes a description superfluous. There is a general resemblance to the dorsal vertebra of an alligator that is very striking. If we compare this highly specialized type with the vertebra of a peacock that flies but little, at the first glance the difference appears very slight, but with a little study the wonderful lightness of the plates in the eagle becomes apparent. Let us now put together the conclusions that seem justified by this series of studies of bones.

We started by accepting as established, that the structure of bone both external and internal, is, in general, correlated with the strain it has to resist, but we found that its external shape is modified so as to give room for the attachment of muscles. The internal structure is not modified to resist the pull of the muscles, except in some few instances, and the fibres of tendon are not continuous with the fibres of decalcified bone.

We find also that the strength of the osseous structure increases with the strain on the bone. Thus the trabeculae of the human humerus are lighter than those of the femur, while in the ungulata they are nearly equal, and the lumbar vertebrae of the whale are intermediate in density to the dorsal and caudal ones.

We find a marked correspondence of structure between homologous parts of bones having nearly the same function, as the proximal extremities of the humerus and femur of the ungulata; and where the function is diverse there is a corresponding difference of structure, as shown by the shorter neck of the humerus and the longer neck of the femur in man and the apes, the traces of the common plan being recognizable.

We find a similar correspondence between non-homologous bones having a nearly similar function, as between the olecranon and the end of the calcaneum in many quadrupeds.

The study of sections of different bones in the same animal, and my observations, are by no means limited to the parts discussed in this paper, shows that certain classes, orders and genera have a characteristic type. The main characteristics of the bones of fishes and birds are too familiar to require mention, and I have not given enough study to reptilian bones to discuss them in detail. Among mammals we find a characteristic structure in the pinnipedia, and another in the cetacea. We find a considerable difference among the ungulata. These features are more marked in some bones of the same skeleton than in others. Beside these peculiarities of the skeleton as a whole, there are occasional appearances that are characteristic of certain animals. Are these teleological?

To consider first the outer shape of the bones, it is hard to believe that the needs for support and motion should be so much alike in the horse and rhinoceros and so different from those of the even-toed ungulata, that the former should require a third trochanter,

and that the latter should not. It is very problematical whether the supra-condyloid foramen of the humerus is of advantage to its possessors, and if so, that it would not be equally useful in species that do not possess it. Why is there a supra-condyloid foramen in the humerus of the seal and none in that of the sea lion? The solid epiphysis of the head of the femur in the kangaroo is not easily accounted for. If it is said that it is to resist the shock of the forcible extension of the femur in jumping, one might ask what explains its appearance, in a less developed form indeed, in the little used anterior extremities, or why it is found in the femur of the opossum. To say that this structure is the result of heredity, gives no explanation of its original appearance. If it is useful one would expect to find it in other leaping animals.

The occurrence of apparently useless rudimentary structures in other systems is so well recognized that there is no *a priori* reason why they should not occur in bones. Professor Heiberg[1] of Christiania has the merit of showing that the lines on the lower end of the human femur, erroneously supposed to be due to the pressure of the semilunar cartilages, are of this class, being, in fact, the representatives of the more marked separations of the patellar and the two condyloid surfaces in many animals. It is not unlikely that many features of the internal structure of bone may have this significance.

It is curious that the two most striking peculiarities of the texture of bone that we have noticed in mammals, are those of the seal on one hand, and whale tribes and the manatee on the other. These aquatic animals resemble one another in the thick layer of fat under the skin and in the flipper-like anterior extremities, though these are rather rudimentary in the whale and highly specialized in the seal, the former having relatively weak muscles and the latter strong ones; but the bones, or at least the larger ones, differ radically in these two types. Each departs from the ordinary plan in an opposite direction, the seal having thick plates and large interspaces; the whales and manatee, very numerous thin plates crowded together. It may be urged that the purpose of the heavy cetacean bone is to resist pressure at great depths, but though this need may exist for the larger whales, it probably does not for several species, and certainly not for the manatee. The bone being then apparently unnecessarily massive in the whale, the architectural plan of the internal tissue seems doubly unnecessary, yet we have seen it beautifully marked in the whale's humerus. In the manatee, especially, there is a strong suggestion of a degenerating type. On the other hand, the structure of the bones of the seal implies at once strength and lightness.

It appears, therefore, evident that so far from the actual structure of the bone being the only possible one, it in many cases presents useless features, and that certainly there must be some determining factor besides teleology. Is it impossible to hold that the vertebrae of an alligator, for instance, could not answer their purpose equally well if the internal structure were more on the plan of mammalian vertebrae? Are there not peculiarities of race that in all cases, at least, do not answer any definite purpose? It seems to me that there can be no reasonable doubt on the matter. It may be urged that we lack the knowledge to decide whether any given organism considered as a whole is or is

[1] Archiv. für Anat. und Entwickelungsgeschichte, 1883.

not as good as its nature admits. It may be urged that an essential element of perfection is the due proportion of parts and faculties, and that it is impossible for us to say that greater development in some particular direction would be for the welfare of the individual. I have no desire to dispute the great truth underlying these propositions, but in view of rudimentary organs alone, it would appear that at least in some subordinate details useless structures occur, and we have no means of deciding what limits to assign to the action of the causes producing them. It is certain that these appearances are not due to chance; there must be some determining cause modifying the structure in this direction. It is customary now to quote rudimentary organs and anatomical anomalies as evidences of descent, but it seems to me very improperly, occurring as many of them do quite out of the line of inheritance. This criticism applies with greatest force to anomalies, but rudimentary organs seem phenomena of the same general class. What principle then shall account for them? We must turn to homologies. We see throughout vertebrates a general plan; and though great modifications occur, the plan persists. No liberties, so to speak, are taken with it beyond a certain point. There are, never, for instance, more than two eyes, or one mouth or four pairs of limbs. Is there reason to be sure that none of these, or analogous modifications, might not be for the benefit of the individual? Yet, I think every student of natural history would look on the suggestion that they will ever occur as chimerical.

The principle of homology has a restraining influence on variations of structure, both in quasi-accidental instances, as in anomalies, and in transformation, of species (if that occurs) by restricting changes within the limits of the general plan.

To condense further these deductions, it appears that the internal structure of any particular bone may show evidence of three factors: first, that of teleology; second, that of homology; third, that of correlation to the structure of other bones of the same animal. The relative prominence of these factors varies greatly. For example, in the humerus of the whale the first is of little moment and so is the third in the heel bone of the seal. Thus, while we find provision for the fitness of the part, we find also sometimes apparently useless structures, sometimes apparently evidences of degeneration, but throughout are more or less distinct marks of harmony with other parts, and of homology with other forms. How has this been accomplished? Clearly the crude notion that accidental, purposeless, external forces should be sufficient to change by slow degrees one such organism into another of a different species is untenable. The doctrine of chances alone shows it to be impossible. There is, moreover, the unanswerable argument of the inevitable uselessness of incipient structures. Where we see the need, we see the structure to meet it already perfect. We see also the combination of homology with teleology. Whatever, therefore, the share of evolution may be in the production of species, it is not one of chance. The changes must be for the most part comparatively sudden, and, therefore, due to an implanted, internal force acting in predetermined directions. On the theory of external accidental forces, the preservation of homology is incomprehensible. The action, however, of this internal force, is, no doubt, modified by accidental secondary causes, which may produce degenerative as well as progressive changes.

In conclusion, I wish to express my sincere thanks to the authorities of the Boston Society of Natural History and of the Museum of Comparative Zoology at Cambridge, for their kindness in allowing me to cut valuable bones. I am indebted for many of the best sections to the skill of Dr. S. J. Mixter, Assistant Demonstrator at the Harvard Medical School. The illustrations are phototypes by the Lewis Company made from photographs taken in every case from the actual specimen.

DESCRIPTION OF PLATES I-III.

Fig. 1. Femur of horse, cut through third trochanter.
" 2. Humerus of man.
" 3. Femur of man.
" 4. Humerus of chimpanzee.
" 5. Femur of chimpanzee.
" 6. Humerus of gorilla.
" 7. Femur of gorilla.
" 8. Humerus of mandrill.
" 9. Humerus of seal (*Phoca vitulina*).
" 10. Femur of seal (*Phoca groenlandica*).
" 11. Humerus of whale (*Globicephalus melas?*).
" 12. Humerus of moose.
" 13. Femur of moose.
" 14. Humerus of hartebeest.
" 15. Femur of hartebeest.
" 16. Femur of kangaroo.
" 17. Calcaneum of man.
" 18. " " chimpanzee.
" 19. " " bear.
" 20. " " lion.
" 21. " " seal.
" 22. Olecranon of man.
" 23. " " lion.
" 24. Vertebra of man.
" 25. " " lion.
" 26. " " horse.
" 27. " " seal (*Phoca foetida*).
" 28. " " whale (*Globicephalus melas?*).
" 29. " " manatee.
" 30. " " horse mackerel.
" 31. " " alligator.
" 32. " " pithon (horizontal).
" 33. " " " (frontal, near posterior end of vertebra).
" 34. " " " (frontal, near anterior end of vertebra).
" 35. " " bald eagle.

II. The Development of the Ostrich Fern, Onoclea struthiopteris.

By Douglas Houghton Campbell, Ph.D.

(Walker Prize Essay, 1886.)

Among the most characteristic ferns of the northern United States are those belonging to the genus Onoclea, represented by three species, two of which, *O. sensibilis*, L., and *O. struthiopteris*, Hoffm., are found throughout the northeastern United States, the latter species, the subject of this memoir, being less generally distributed, though locally abundant. It also occurs throughout northern Europe and Asia.

The sporangia in this fern are borne in great numbers on the back of the fertile fronds, and as these remain standing through the winter after the sterile fronds have decayed, spores can be obtained at all seasons of the year. These retain their vitality for several months after being gathered, so that when the plants are common, abundance of material is constantly on hand. This fact, together with the ease with which the spores can be germinated, makes the plant a specially valuable one for study.

The observations here recorded were begun in the spring of 1882, and were continued, with more or less interruption, through the autumn of 1885. The points of most importance discussed are the following:

The presence of a third coat in the spore.

The marked dioecism displayed by the prothallia.

Formation and development of the apical cell of the prothallium.

Continuity of the protoplasm in the cells of the prothallium.

Development of the antheridium and antherozoids.

Absence of the ventral canal-cell in the archegonium.

Succession of the divisions of the embryo and the establishment of the apical cells of its different members.

Development of the different tissues of the embryo.

Development of the leaf from the apical cell, and the relation of the different tissues of the leaf to the segments of the apical cell.

Method of formation of the pinnae.

Development of the stem from the apical cell.

Development of the sporangium.

Section I. Prothallium.

The spores are of the so-called bilateral form, oval in shape and protected by a firm, dark brown outer coat, the exospore, which is provided with ridges or folds, usually arranged so as to enclose an irregularly polygonal area, other ridges running from the angles. The spore is slightly flattened on the side originally in contact with its fellow, in the mother-cell, and the exospore on this side is smooth. Besides the exospore there are two other coats: a middle one that does not appear to have been previously noted in ferns, and the endospore. The middle coat is not readily seen before germination, but that it is not unmodified cellulose is shown by the fact that the prolonged action of sulphuric acid and iodine does not color it blue. It is plainly seen in cases where the opaque exospore has become detached before germination, as it must be ruptured before the endospore can protrude. The exospore seems to be only slightly attached, readily separating on slight friction, and is often thrown off by the swelling of the spore on the absorption of water.

On examining dry spores after the removal of the exospore, they are found to be flattened on one side, but in a few minutes after being placed in water, by its absorption they become distended and all trace of flattening disappears, the spore then being almost perfectly oval in form (Pl. 4, fig. 1). They contain abundant chlorophyll which is sometimes nearly uniformly distributed throughout, but is commonly more abundant in the center. Besides the chlorophyll, the protoplasm contains other granules, not, however, of starch. Oil is often to be detected in drops of considerable size but is usually uniformly distributed. At the center of the spore, but usually nearly concealed by its dense contents, is a small, but sharply defined nucleus

Under favorable circumstances, the spores begin to germinate in from three to five days. The early stages can best be observed by simply growing the spores in water, and keeping them in a warm place in a moderately strong light; but perfect prothallia cannot be thus obtained.

The first sign of germination, in cases where the exospore has been thrown off, is a splitting of the second, or middle coat, for nearly the whole length of the spore, and through the fissure thus formed the endospore protrudes (Pl. 4, figs. 2, 3). Usually one end of the spore at this time is more transparent than the rest, being wholly, or in part, destitute of chlorophyll. This transparent end becomes shut off from the body of the spore by a septum nearly at right-angles to the longer axis of the spore, and becomes the first root-hair (Pl. 4, figs. 2–4, 6). This elongates rapidly, attaining in the course of two or three days four or five times the length of the original spore. The body of the spore has also elongated by this time to more than twice its original size, and becomes further divided by a septum nearly parallel to the first. The terminal cell continues to increase in length, and new septa parallel to the first are formed thus causing the prothallium to assume the filamentous or protonemal stage (Pl. 4, figs. 4, 6). By the end of the first week many of the prothallia show divisions at right angles to those first formed, this sometimes occurring in the second or third cell, but not usually until a row of three or four cells has been formed. About the same time a second root-hair is formed from the basal cell. A small papilla is formed on one side which is cut off from the cell

by a septum, and rapidly elongating assumes the form of the first (Pl. 4, fig. 5 *r'*). Like this it contains little or no chlorophyll. As growth progresses the chlorophyll granules, which had at first been crowded together, become more separate and very distinct. The protoplasmic layer in which the chlorophyll granules are embedded lines the walls of the cells, the center of the cell being occupied by a large sap-cavity. The nucleus, which is sharply defined, and usually contains an evident nucleolus, is round in outline, and lies close to the wall of the cell. In the root-hairs the protoplasm, near the growing end, is finely granular, and a few larger granules are scattered through the peripheral protoplasm. In the young hairs, some of these are faintly colored with chlorophyll but this seems to be finally lost.

If the protoplasm of the cells of the prothallium is contracted, *e. g.*, by a solution of sodium chloride, and then stained, the continuity of the protoplasm can be easily demonstrated. Delicate threads of protoplasm can then be detected connecting the protoplasmic masses of adjacent cells, apparently passing through small openings in the wall.

By the end of the second week the flattened form of the older prothallia begins to be marked, on account of the division of the cells in two planes, and about a week later the larger ones show the beginning of the sinus in the front margin, causing it finally to assume the heart-shape usually met with in the larger prothallia of ferns. This form is usually quite pronounced by the end of the first month (Pl. 4, fig. 13). It is brought about in the following way: after a row of several cells has been formed, the terminal cell becomes divided by a wall nearly at right angles to the earlier ones. In the cells thus formed, transverse walls are formed which, however, generally diverge somewhat from an exact right angle with the median wall, being turned slightly forward, thus forming two cells that are nearly triangular in shape. One of these becomes the apical cell of the prothallium, the other behaving like the ordinary cells. The apical cell becomes next divided by a wall parallel to one of its lateral walls, and next by a similar one parallel to the other side. This process is repeated, resulting in two series of segments lying alternately right and left, thus rapidly increasing the breadth of the apex of the prothallium (Pl. 4, figs. 7–11). Occasionally, two segments appear to be cut off from the side in succession, but this is probably exceptional. The first division in each segment is transverse, and divides it into an inner and an outer cell. The succeeding divisions do not always follow the same order, but usually the next wall divides the outer cell into two equal parts, and is perpendicular to the first one. Following this, the inner cell is divided into two by a transverse wall. Beyond this point there is great irregularity. However, the longitudinal growth of the segment exceeds the lateral growth, so that the end of the segment is pushed out beyond the apical cell. This combined with the rapid division of the marginal cells of the segment results in the formation of a deep sinus or cleft, in the front of the prothallium, in the bottom of which lies the apical cell. Where this growth is excessive, the two lobes of the prothallium sometimes overlap. Sooner or later the apical cell ceases to form lateral segments, and becomes divided by a transverse wall into an inner and an outer cell, in the same way that the segments were first divided (Pl. 4, fig. 12). The outer cell divides into two equal cells by a wall at right angles to the first, and the apical cell thus becomes obliterated, acting from this time on like the other cells. In cases where the prothallium is branched, as

frequently occurs in the male prothallia, a new apical cell, dividing in the same way as the original one, may be formed at the end of a branch. One case was observed where the prothallium was divided into two branches, each having a perfect apical cell, the whole looking very much as if these two cells had originated from a bipartition of the original apical cell.

Soon after the obliteration of the apical cell, or sometimes before, the cells in its vicinity, which hitherto have divided in two planes only, now divide also by walls parallel to the surface of the prothallium, thus giving rise to a mass of cells occupying the bottom of the cleft in its front. In cases where the prothallium continues to grow for a long time and this process begins early, a thickened mid-rib is formed, running for nearly its whole length.

The foregoing account applies only to the larger prothallia, which are, for the most part, female. Many exceptions occur in the male prothallia, and the younger prothallia that are exposed to unfavorable conditions. If the spores are germinated in water, the cells become much longer and more slender, sometimes attaining four or five times the normal length without dividing. On the other hand, prothallia grown under normal conditions are to be met with in which no protonema is formed, but the second cell of the prothallium dividing by a longitudinal wall, the flattened form is assumed almost from the beginning. Where the spores are sown thickly, the male prothallia sometimes do not pass beyond the protonemal stage, the row of cells being terminated by an antheridium, and these simple prothallia are sometimes destitute of any root-hair (Pl. 4, fig. 15). While many of the male have much the form of the female, differing simply in their smaller size, they are more commonly of very irregular shapes, especially if they have attained some size, often being much branched and lobed, reminding one strongly of those of certain species of Equisetum. In some irregular forms, either no definite apical cell is formed, or else it is early lost.

Under favorable circumstances the first antheridia are mature in from five to six weeks from the time the spores are sown, and the first archegonia about three weeks later. With care they can be kept alive for a comparatively long time. A quantity of prothallia raised from spores sown Aug. 31, 1884, were kept through the winter, growing but little for about two months, from the last of November. They were removed to a warm room in January and given abundant light and moisture. Growth was resumed and an abundance of antheridia and archegonia were produced. The greater part of the female prothallia produced young plants, but a few that were not fertilized were alive a full year from the time that the spores were sown. Most of the male prothallia had died a month or two previously. As the growth of the prothallium continues, new root-hairs are formed from the cells near its base; these arise sometimes from the margin, but more commonly from the lower surface of the cells; in exceptional cases from the upper surface.

Section II. The Sexual Organs.

The antheridia originate in the same way as the root-hairs. In the young prothallia they arise from the marginal cells; in the older ones, from the upper and lower surfaces as well. They begin as small prominences, usually close to the wall separating two ad-

jacent cells. The protoplasm in the papilla is dense, especially in the middle, and contains small chlorophyll granules. A septum is then formed, by which the papilla, now the mother-cell of the antheridium, is shut off. This may be followed by a second wall parallel to the first so as to form a pedicel, but this is unusual (Pl. 4, fig. 29, P). Ordinarily, the first wall to be formed in the mother-cell is funnel-shaped, the base of the funnel being upward and the smaller end of the funnel in contact with the wall by which the mother-cell was first cut off (Pl. 4, fig. 16). Sometimes this wall is almost flat, or it may be convex downward but not reaching to the base of the antheridium. The second wall (Pl. 4, fig. 17) is nearly constant in form, dome-shaped or hemispherical and follows pretty closely the outline of the antheridium which has by this time grown rapidly and become nearly globular in shape. Finally, a third wall is formed in much the same way as the first, and like it subject to considerable variation (Pl. 4, fig. 18). The cell thus formed is the cap-cell and has its inner surface in contact with the upper part of the second wall. The antheridium now consists of four cells: an inner cell containing dense, finely granular protoplasm, but no chlorophyll; and three others which surround this, in which there is less protoplasm, but some small chlorophyll granules. Of the three outer cells the two lower are thus annular in form, except in cases where the first wall formed is not sufficiently convex to touch the basal wall of the antheridium, in which case the lower cell is discoid. About the time the cap-cell is formed, or sometimes before, the central cell begins to divide. The first wall (Pl. 4, fig. 20) is vertical, dividing the cell into nearly equal parts. This is followed by a second vertical wall (Pl. 4, fig. 23) at right angles to the first, so that when the antheridium is seen from above, the cells are arranged like quadrants of a circle. These undergo further divisions (Pl. 4, fig. 22) until there are about twenty cells. Their form is polyhedral, but the outer walls are rounded so that those on the outside of the mass appear almost globular. The protoplasm is highly refractive and finely granular and each cell is provided with a small but evident nucleus.

As soon as the sperm cells are fully grown the formation of the antherozoids begins. The protoplasm becomes somewhat more coarsely granular and the nucleus indistinct, though it does not actually disappear and can usually be demonstrated by staining. When it becomes more evident again, it is seen to have changed form and to have increased in size (Pl. 4, fig. 25). Instead of being globular, it is now crescent-shaped. It grows larger, becoming at the same time more curved (Pl. 4, fig. 26). This continues until it is soon evident that what was the nucleus of the cell is assuming the appearance of the complete antherozoid. Growth continues until the body of the antherozoid is in contact with the wall of the mother-cell, and lies coiled up within it, leaving, however, some remains of the protoplasm of the mother-cell lying between the coils. When the antherozoids are nearly mature, the walls of the sperm cells, which were hitherto in close connection, become partially absorbed leaving the separated sperm-cells free in the cavity of the antheridium. If an antheridium, in which the walls of the sperm-cells have undergone degradation, is placed in water, a very marked movement of the contents of the antheridium may sometimes be observed, due apparently to the absorption of water by the mucilaginous walls and their breaking down and dissolving through its action. Enough of the wall is left, however, to still enclose the antherozoid. By the time that they are ready to escape, the sperm-cells are so crowded as to press with sufficient force against

the walls of the parietal cells to diminish their cavities very considerably (Pl. 4, fig. 24). These cells at the same time absorb much water, and if a ripe antheridium is placed in water, the tension resulting from the combined pressure of the cells within, and the turgidity of the parietal cells from the absorption of water, are sufficient to cause a rupture in the wall of the antheridium. This usually takes place between the two upper cells, the cap-cell being torn in the operation, but sometimes by a rent in the cap-cell only. As this occurs the lower parietal cells become much swollen and press inwards upon the mass of sperm-cells which are thus forced out through the opening. Their discharge is accompanied by a small amount of mucilaginous matter, evidently the remains of the disintegrated walls of the mother-cells. After lying quiescent for a few moments (Pl. 4, fig. 27) the vesicle in which the antherozoid is contained bursts and the antherozoid swims rapidly away with a twisting movement due to its spiral form. It consists of hyaline protoplasm, somewhat flattened and enlarged at the forward end, which sometimes shows two or three indistinct and close coils, the hinder part being composed of one or two open and complete turns of the spiral (Pl. 4, fig. 28). The cilia are numerous, being developed principally on the anterior coils but also extending back to the beginning of the larger ones. They are directed somewhat backward, as is plainly seen in treating the antherozoid with iodine, which causes it to become deeply stained and somewhat contracted and the cilia rigid and sharply defined. The end tapers to a point which sometimes is much prolonged. When the antherozoid has recently escaped, the movement of the cilia is so rapid as to render them almost invisible, but as it dies the movement becomes slower and is then seen to be undulatory, the movement seeming to begin at the point nearest the body and to proceed outward toward the tip of the cilium. This movement continues for some time after it ceases to be strong enough to propel the antherozoid.

It sometimes happens that the antherozoid does not become entirely free from the membrane of the cell in which it lies so that its movements are much hampered, the vibrations of the cilia being only sufficient to cause a rotation of the cell. It may subsequently free itself entirely or it may never escape completely. As the antherozoid swims away, there is seen attached to it a delicate vesicle which absorbs water and becomes much distended. Contained in this are several fine granules, the whole being the remains of the mother-cell of the antherozoid. This vesicle is sometimes attached to the pointed end of the antherozoid, sometimes it adheres for a considerable part of its length.

It occasionally happens that the antherozoids are imperfect in form, the hyaline protoplasm that constitutes the body not being sharply differentiated from the granular protoplasm of the central parts of the mother-cell. In such cases the antherozoid is club-shaped with the cilia at the pointed end, and the movement is less decidedly rotary.

The archegonia, like the antheridia and root-hairs, arise from the superficial cells of the prothallium and are, therefore, morphologically trichomes. Unlike the antheridia they are confined to a special part of the prothallium, being formed only on the lower surface of the cushion of tissue which lies at the bottom of the cleft in the front of the prothallium. If the earlier archegonia are not fertilized, new ones continue to form as long as the prothallium grows, the latter in such cases reaching a considerable size and bearing, sometimes, a hundred or more archegonia. In such cases, the cushion of tissue,

elongating with the prothallium, forms a sort of mid-rib leaving the remainder of the prothallium a single layer of cells. In these large prothallia the edges are usually decidedly wavy.

The mother-cell of the archegonium (Pl. 5, fig. 3) is not easily detected at first, resembling in shape and size the other young cells in the vicinity. Careful examination, however, usually makes it distinguishable. Its shape, like that of many of the surrounding cells, is that of a truncated pyramid, the base being at the surface of the prothallium. Viewed from above it appears nearly square. The contents are quite different from those of the neighboring cells. In the latter, the protoplasm together with the chlorophyll-granules and nucleus is confined to the parietal parts of the cells, the center containing only cell-sap; in the mother-cell of the archegonium, on the contrary, the protoplasm appears to be more dense occupying nearly or quite all of the cell. The chlorophyll granules are smaller, less numerous and distinct, while the nucleus is not only larger but nearly central in position instead of lying near the wall.

The first step in the further development of the cell is a slight elevation of the outer wall above the level of the neighboring cells, the upper part of the cell becoming usually more transparent. Next, the cell becomes divided into two unequal parts by a transverse wall; the lower cell undergoes no further change beyond simple division, taking no further part in the formation of the archegonium, but acting in all respects like the vegetative cells of the prothallium. The upper and larger cell next divides by another wall parallel to the first, but more or less convex, the outer of the two cells thus formed containing less protoplasm than the lower and forming the beginning of the neck; the lower, filled with dense protoplasm and containing a large central nucleus, is the central cell from which is finally developed the germ-cell (Pl. 5, fig. 4). The upper cell now becomes divided by a wall at right angles to the longer axis of the prothallium into an anterior and posterior cell; this wall is sometimes vertical, but more commonly inclined backward so that even from the first, the anterior part of the neck is larger than the posterior (Pl. 4, fig. 31, Pl. 5, fig. 2). A wall is next formed at right angles to the first so as to divide the cell into four parts (Pl. 5, fig. 1). These are the beginnings of the four rows of cells composing the neck of the mature archegonium. The protoplasm of these cells is nearly destitute of granules, so that they are nearly colorless, and this characteristic is maintained. Of the four cells into which the primary neck-cell is first divided the two lying in front grow more rapidly than the others, so that the neck very early shows a decided curvature backward, the amount of curvature depending largely upon the degree of inclination of the first formed wall. Each of the four cells next divides by a transverse wall and later by a series of walls parallel to the first (Pl. 5, fig. 2). The first of these walls seems to appear somewhat earlier in the two anterior cells, the two rows of neck-cells developed from these containing, usually, about two more cells than are found in the other two, there being ordinarily six or seven in the anterior, four or five in the posterior rows.

Each neck-cell in the mature archegonium has a distinct nucleus lying close to the wall, the latter being lined with a thin layer of very finely granular protoplasm in which are embedded a few larger granules, some of which show a faint greenish color. With this exception the contents of the cells are perfectly colorless (Pl. 5, figs. 6, 7).

While the neck-cells are growing, the central cell of the young archegonium is also undergoing changes. The wall by which it was separated from the primary neck-cell becomes more decidedly convex and pointed, pushing up between the four rows of neck-cells. About the time that the first transverse septa are formed in the neck-cells, the upper pointed part of the central cell becomes cut off by a septum which is concave upward, from the main part of the cell (Pl. 5, fig. 2). The upper cell becomes the canal-cell of the neck; the lower, the central cell, from which finally the germ-cell is formed. Although a very large number of archegonia in all stages of development were examined, no trace of any further division of either central cell or canal-cell could be detected beyond the presence in the latter of several nuclei, it appearing probable that in this case, at least, the so-called ventral canal-cell of Janczewski does not exist.

In its earlier stages the canal-cell is sometimes quite conspicuous, but as it becomes older its outlines are not so definite. The protoplasm is colorless and densely granular, and frequently several nuclei can be detected but no division-walls, except the first one by which it is shut off from the central cell. It continues to elongate as the neck of the archegonium grows, reaching as far as the base of the upper cells. When the archegonium is ripe, the wall separating the canal-cell from the central cell becomes mucilaginous, and probably also the inner layers of the walls of the neck-cells, in a manner analogous to that described in the case of the antheridium. If now water is applied, the walls of the cells dissolve and the space occupied by the neck-cell becomes filled with a colorless mucilage derived from the disintegrated cell-walls, together with the protoplasm of the cell. This change is accompanied by active movements of the contents of the canal, the movements being very marked and lasting for about a minute. This was observed only in a single instance, but from the resemblance to what takes place in the antheridium, is probably the normal process. After the movements had ceased it was seen that the more solid portions of the contents of the neck had collected in a row of two or three pretty distinct masses, the lower one of which was somewhat rounded, corresponding in appearance with Sach's figure of the central canal-cell (Pl. 5, fig. 6). It is possible that this, which is undoubtedly only part of the contents of the canal-cell, may from its appearance have been considered as a separate cell. There is not always, however, this separation of the granular part of the contents, but in many cases the contents appear the same throughout.

Probably at the same time that the change described in the neck-cells takes place, but which could not be determined with absolute certainty, the contents of the central cell, which have hitherto been uniform, undergo a change. The protoplasm contracts into a spherical mass which does not completely fill the central cell; this is the germ-cell or oösphere. It contains a large central nucleus and in favorable cases a transparent area can be detected lying on the side nearest the neck, this being the receptive spot; the rest of the protoplasm is colorless but densely granular. The central cell increases in size but little from the time it is first formed; it is surrounded by a single layer of small cells cut off from the adjacent cells of the prothallium including the basal cells of the archegonium, which usually becomes divided into two nearly equal cells, but otherwise is unchanged in appearance and easily identified. Thus the basal part of the archegonium is completely embedded in the prothallium; the neck alone projecting beyond the surface.

The neck-cells of the ripe archegonium possess the same property of absorbing large quantities of water that was observed in the parietal cells of the antheridium; and becoming much swollen the pressure exerted upon the contents of the canal is sufficient to force apart the upper neck-cells, which finally diverge widely, allowing the contents of the canal to escape, leaving a clear passage down to the germ-cell (Pl. 5, fig. 7). This process can be easily seen by allowing prothallia upon which there are mature archegonia to remain somewhat dry for two or three days. Longitudinal sections of these being made and mounted in water will be certain to show some archegonia ready to open, and generally within a few minutes sufficient water will have been absorbed to force open the neck and discharge its contents. For a satisfactory study of the development of the archegonium, these longitudinal sections of the prothallium are necessary, archegonia in all stages of development being found in the older prothallia.

The upper cells of the archegonium separate slowly at first, this being accompanied by a slight discharge of mucilage. As water continues to be absorbed by the neck-cells, they become much swollen and the upper cells are torn apart, often with violence enough to detach entirely some of the uppermost ones. At the same time, by the inward pressure, the remaining masses of mucilage are forced out, collecting in masses of some size around the opening of the archegonium (Pl. 5, fig. 7). Besides the granular masses which are mainly composed of the protoplasm of the neck-cell, there is a quantity of viscid, perfectly colorless and transparent matter, whose presence is made evident by the behavior of the antherozoids that come in contact with it. The antherozoids collect in greater or less numbers about the month of the open archegonium, their movements being retarded by the mucilaginous matter expelled from the neck, but by far the greater number are not detained by the mucilage, or only temporarily; and of those held, only a very small part ever enter the archegonium. When an antherozoid comes within the immediate vicinity of the archegonium, its movements are very much checked, there being evidently some substance present that interferes with the free movements of the cilia. One may frequently be seen to come to a sudden stop, and after vigorous efforts to free itself, swim away with undiminished vigor. The canal of the archegonium appears to be filled with the same substance, for although nothing is visible the movements of the antherozoids are so much checked that in nearly every case observed, they failed to penetrate to the germ-cell, although making their way for some distance down the neck. This necessitates the fertilization of the germ-cell by a fresh and active antherozoid, as only such would have strength to make its way down to the germ-cell.

The entrance of the antherozoid into the neck of the archegonium was observed a number of times, and in one case one was detected within the central cell. Before entering the movements cease almost entirely for a few moments, and are then resumed, the body being somewhat stretched and the movement slowly rotary; at the same time, by a quick movement of the pointed end of the body, the vesicle is thrown off (Pl. 5, fig. 9).

In the single case in which the antherozoid was observed within the central cell, the form of the antherozoid could not be clearly made out, though the movement of the cilia was plainly seen for several minutes, when it ceased, and the antherozoid became lost to view, presumably fusing with the germ-cell, but its mode of entrance could not be made

out. The neck-cells of the same archegonium, examined twenty-four hours later, showed a decided brown color, which was not observed in unimpregnated archegonia of the same age, and the germ-cell had divided (Pl. 5, fig. 10).

In making experiments in fertilization, a number of male prothallia, freed from earth, were placed upon a slide, and with them longitudinal sections of female prothallia, some of which are almost certain to contain ripe archegonia. If the prothallia have been kept somewhat dry for two or three days, especially in warm weather, both archegonia and antheridia will open very soon after they are placed in water. In this way freshly opened archegonia and numerous antherozoids were present upon the slide, and could easily be observed, but although many trials were made, the antherozoids in the great majority of cases failed to enter the archegonium at all.

The prothallia are always strongly dioecious, the male prothallia never bearing archegonia, and the female only in rare cases developing antheridia, and then only in small numbers, and before the archegonia are mature.

Various experiments were made to find out what were the most favorable conditions for growing the spores, and several were more or less successful. The earliest stages can best be observed by placing the spores simply in water, as they are then free from foreign matter; but they do not develop in a healthy manner if left in water, the prothallium becoming very long and slender, the transverse septa being wanting, or only developed at long intervals. Finding that some fern prothallia grew naturally on rotten wood, spores that had germinated in water were transferred to this material and developed male prothallia, but no female ones. Probably further trials might have been more successful. The best results were obtained by sowing the spores in fine earth in shallow earthen saucers which were kept under glass to prevent too rapid evaporation. In cold weather, they were exposed to direct sunlight, but in warm weather were kept partially shaded. Care must be taken not to keep them too wet, for if they are kept soaking wet for a few days they are apt to decay, besides inducing a growth of algae, such as Oscillaria, etc., which sometimes interfere with the growth. In cultures that have been kept for some months, it is almost impossible to prevent the growth of mosses, whose protonema, unless kept down, sometimes interferes with the ferns; but if the prothallia are well established, a little care in removing the mosses from time to time will be sufficient. Severe freezing failed to kill the prothallia, provided care was taken to thaw them out gradually.

Attempts to grow the prothallia in porous pottery met with indifferent success.

All of the prothallia, from which the foregoing observations were made, were grown artificially, none having been met with growing naturally.

Section III. The Embryo.

The first division of the germ-cell is completed within twenty-four hours after fertilization and is effected by a wall (the basal wall) which is slightly inclined to the surface of the prothallium and perpendicular to its longer axis. The basal wall may be inclined either toward the front or back of the prothallium and divides the embryo into two cells, the epibasal lying in front, and the hypobasal behind (Pl. 5, fig. 15). Each of these cells is next divided by a wall (the transverse wall) perpendicular to the basal wall and

parallel to the surface of the prothallium, so that the four-celled embryo, seen from above, appears to have only two cells (Pl. 5, figs. 11, 17). Each of the four cells is next divided by a wall (the median wall) parallel to the long axis of the prothallium, so that the embryo now consists of eight cells arranged like the octants of a sphere.

Up to this point, as far as is known, the majority of ferns seem to agree, except as to the relative time of the formation of the transverse and median walls, which appear in different order in different species. As to the further history of the eight primary cells of the embryo, there is considerable disagreement. After repeated examination of a large number of specimens, the following conclusions have been reached with reference to the fern under consideration.

If we examine again the eight-celled embryo, it is easily seen that each one of the cells is nearly tetrahedral in form; that is, the walls that bound the faces that are in contact are approximately plane triangles, the outer wall a spherical triangle. Each of the eight cells thus *has the form characteristic of the apical cell of the mature stem and root.* For a short time these all grow in essentially the same way as the apical cells of these organs, but this growth is checked in all but those two that finally assume the function of these two cells.

Of the four cells first formed, the two lying in front of the basal wall give rise to the first leaf and the stem; those of the hypobasal half of the first root and foot (Pl. 5, fig. 11). Of the epibasal portion, the one next to the neck of the archegonium forms the first leaf, the other the stem; of the hypobasal half, the lower (next the neck of the archegonium) the first root, the upper the foot.

The first divisions are essentially the same in all the octants, though there is slight variation in some cases. The first wall (Pl. 5, fig. 14, 1) is usually parallel to the basal wall, and is soon followed by a second, parallel to the transverse wall; sometimes this order is reversed, but never, so far as could be made out, was the first wall in the octant parallel to the median wall. Before any further segments are cut off from the primary cells (octants), these first segments undergo further divisions. Each one is divided into two cells by a tangential wall, an inner and an outer cell (fig. 13). Each octant now consists of five cells, two inner and three outer, one of the latter being the primary cell which still retains its tetrahedral form. After a segment has divided into an inner and an outer cell, the latter becomes divided into two by a radial wall, but beyond this the succession of walls differs. Of these eight tetrahedral cells, four, one in each quadrant of the embryo, soon lose their primitive form: indeed this sometimes occurs even before the second set of segments is cut off from the primary cells. This is brought about as follows: In one of the primary cells of each quadrant, after the first or second divisions have taken place, instead of new segments being cut off in the same way, a tangential wall is formed, dividing the primary cell into an inner and an outer one. The outer one is divided by radial walls; and the inner, dividing by walls directed in various directions, soon becomes indistinguishable. There are thus left remaining four of the primary cells, as the apical cells of each quadrant. Of these, those of the stem and root remain unchanged; that of the leaf undergoes some further changes, to be presently described; while that of the foot, after one or two more sets of segments have been cut off, is divided by a tangential wall into an inner and outer cell, in the same way described in the other primary cells, and thus ceases to act as an apical cell.

Although the apical cell of the first leaf is at first like that of the other quadrants, tetrahedral, after about two sets of segments have been cut off, no more — or at any rate, no more, as a rule — are cut off from the side parallel to the transverse wall. The succeeding segments are formed alternately from the sides originally parallel to the basal and median walls. By the obliteration of one of the original cells of the leaf-quadrant, and by subsequent growth and consequent displacement of cells, the apical cell of the leaf, as seen from above, occupies nearly the center of the leaf-quadrant (Pl. 6, fig. 1). As a result of the formation of segments in two directions only, the apical cell loses its original tetrahedral form, and approximates the wedge-shaped apical cell of the later leaves. Some time before the embryo is ready to break through the enveloping tissue, a further change takes place in the apical cell of the leaf. It undergoes division, each half assuming the form of the original, and becoming the apical cell of one division of the strongly two-lobed leaf (Pl. 6, fig. 3). The division takes place as follows. The apical cell is divided into two equal parts by a vertical wall. Each of the resulting cells is next divided by a curved wall running from the outer margin of the cell to the wall that belonged to the original cell. There are thus formed four cells, the two central ones being elongated, the others nearly triangular in outline. The former become divided by a transverse wall into an inner and outer cell; the two latter by walls alternately right and left: being, in fact, the apical cells of the lobes of the leaf.

The young leaf grows much more rapidly than the stem, and soon projects beyond it. The multiplication of the cells being greater on the lower side, the leaf begins to curve upward. The cells of the leaf-stalk now elongate rapidly, and after the embryo has broken through the overlying tissue of the prothallium, the leaf pushes up between the lobes of the prothallium, appearing above its surface (Pl. 6, fig. 5).

The apical cell of the stem divides much more slowly, and follows nearly the same plan at first. The segments later divide somewhat differently, the first division wall of the segment being a radial one, and dividing the segment into two nearly equal cells. The stem is very short at the time the embryo breaks through the prothallium, but the apex is more decidedly conical than is the case in the mature plant.

The apical cell of the foot soon becomes obliterated by a process entirely similar to that already described, but the cells continue to multiply rapidly with no regular order. By means of the foot, which when complete is large and rounded in shape, the embryo is kept in close connection with the prothallium, and by means of it the embryo is nourished until the first leaf and root are developed.

After the first segments are cut off in the apical cell of the root, it usually continues to act for some time like that of the stem, the first wall of the segment being radial instead of tangential. Of the subsequent divisions, the tangential are much more numerous than the radial. After a varying number of segments have been cut off as described, a wall is formed in the apical cell parallel to its outer surface; this is the first cell of the root-cap. This cell becomes divided by a vertical wall into two, and next by a wall at right angles to the first, into four. Others are formed later, but only in two planes, there being no tangential walls formed (Pl. 5, fig. 16, Pl. 6, figs. 2, 4). From this time on, each cycle of segments in the apical cell consists of four cells. The development of the root varies greatly at the time the embryo breaks through the prothallium. In the majority of cases examined (fig. 2) the root was much shorter than is usually figured

in other ferns at the same stage, and this corresponds with the comparatively late appearance of the first cap-cell; but it was not uncommon to find specimens, in which the root has attained considerable size at this time, and indeed is the first part to break through the prothallium. The root-cap in such cases is composed of several strata, and the first cap-cell must have been formed much earlier.

Shortly before the embryo breaks through the prothallium, the first traces of the primary fibro-vascular bundles are formed (Pl. 6, fig. 2). In the central row of cells, in each of the four members of the embryo, is formed almost simultaneously, a series of longitudinal walls, by which there is formed a central bundle of narrow cells, the procambium of the bundles; hence the primary fibro-vascular bundles must be regarded as distinct, and entirely independent of each other. Of these four bundles, that of the foot is short, and ends blindly within that organ, but the others continue to lengthen with the growth of the organ to which they belong, and shortly after the breaking through of the embryo, the permanent elements of the bundle begin to develop. The stem grows slowly, but the leaf and root with great rapidity; the former, even before the emergence of the embryo, being evidently two-lobed. The apical cells of these lobes also undergo bipartition, so that all the divisions of the primary frond are the result of strict dichotomy. Small glandular hairs appear upon the young leaf, and root-hairs from the surface cells of the root, even before any definite epidermis can be detected. The root rapidly grows downward, the first leaf enlarges and the prothallium, which had hitherto nourished it, withers away and disappears leaving the young plant firmly fastened to the ground.

The primary bundles are arranged like a cross, two of the arms being longer. The longer arms are the bundles of the leaf and root. The first tracheary tissue begins to form about the time that the embryo breaks through the prothallium. Faint thickenings make their appearance on the walls of certain of the procambium cells which soon assume the form of scalariform tracheids. The pits are shorter than in the later tracheids, and there are usually two or three rows. There are no true vessels, the tracheary tissue consisting throughout of single cells or tracheids.

As the leaf-stalk lengthens, its primary tracheids continue to form through the center of the bundle, and around them other spiral ones are developed, growth proceeding from the center toward the circumference of the bundle. The other elements of the bundle follow, but are never perfectly differentiated, consisting simply of elongated, narrow cells with thin walls and colorless contents. These do not taper at the ends but are abruptly truncate, the septa being more or less oblique. The same form of bundle is found in all the earlier leaves, none but spiral tracheids being found in them. The later tracheids are broader than the primary ones and the spirals not so close together. Although there is no distinct bundle-sheath, the bundles are pretty well defined on account of the large size of the cells of the surrounding parenchyma, which are very different from the narrow cambiform outer cells of the bundle.

As might be expected, the veining of the leaf is dichotomous. The bundle in the stalk forks at the base of the lamina, sending a branch to each lobe; these branches fork, and their divisions also; the last veins thus formed may or may not divide once more.

In the first root, the primary tracheids are central, as in the leaf, and the development

proceeds outward. The tracheids are all short and pointed, forming a cylinder which constitutes the greater part of the bundle. They are marked with transversely elongated pits, or with shorter ones placed in two or three rows. The remainder of the bundle consists of one or two layers of narrow cells surrounding the tracheary tissue, their cells having more or less oblique transverse septa. The ground tissue of the root consists of about four layers of large parenchymatous cells, about three times longer than broad. In those nearest the base of the root, chlorophyll is present, but it is wanting in the subterranean parts. The cells of the outer layer differ but little in form from those of the ground tissue, except in being narrower, but their walls soon become brown and thickened, and, finally, the contents disappear, leaving them dry and scaly. From the outer surface of the cells abundant root-hairs are formed.

The second root, like all the subsequent ones, is endogenous in its formation. The apical cell is formed in the tissue at the base of the second frond near the point at which the bundle of the leaf connects with that of the stem. As the root grows, its central cells become divided by longitudinal walls into a cylindrical mass of cells, the procambium of its fibro-vascular bundles, its growth beginning with the cells that lie in contact with the bundle of the stem. The formation of the second root begins while the second frond is still young and before it is unrolled. The root breaks through the base of the leaf about the time that the frond unrolls. The tip of the root contains enough chlorophyll in very fine granules to give it a decided green color; this, however, not extending for any great distance, the cells nearer the base being nearly colorless. The first development of permanent tissue in the bundle takes place at two points instead of one. Two rows of narrow spiral tracheids are formed simultaneously near the foci of the elliptical bundle, and the development of the tracheary tissue proceeds inward. The rest of the bundle is composed of narrow elements similar to the corresponding tissue of the first root.

The bundle of the young stem is solid instead of being a hollow cylinder as in the mature plant. This is partly composed of scalariform tracheids which are short and pointed and rather broad. There are also spiral and reticulate ones, especially in the center of the bundle. The bundle anastomoses with the base of that of the first frond, the tracheary tissue of the two bundles being in contact. The bundle runs toward the second leaf into which it sends a branch, but tracheary tissue is developed in the stem-bundle beyond the point of contact of the two bundles before any tracheary tissue is developed in the bundles of the leaf. As in the case of the other bundles, no other tissue than the tracheary is completely differentiated.

The procambium of the stem-bundle can be traced nearly to the apex of the conical growing point which soon becomes so covered with the broad scales that it is often difficult to get at it.

The young plant grows rapidly. By the time that the third or fourth leaf is fully developed, the stem has assumed some size and the bundle running through it has become sharply differentiated by the formation of a bundle-sheath whose cells assume a brown color. New roots continue to form endogenously from the bases of the young fronds, the formation beginning before the leaf is fully grown.

The new leaves arise from segments of the apical cell of the stem, and up to the fifth

or sixth and probably until the stem reaches its permanent form, the apical cell undergoes bifurcation so that at an early period they consist of two nearly equal lobes. Just how far the subsequent branching of the leaf is due to dichotomy is difficult to determine, but probably in the later formed fronds of the young plant it does not continue beyond the first division, the later divisions, as in the fronds of the mature plant, being monopodial.

A cross-section of the stem of a plant with three leaves completely developed showed that the stem-bundle was elliptical in outline. The center was occupied by a mass of elongated parenchyma cells lying outside of which was a mass of short spiral or reticulate tracheids. Next followed two or three layers of elongated cells much like those occupying the center of the bundle, and surrounding the whole a bundle-sheath formed of narrow cells with brown walls. From the stem-bundle the bundles going to the leaves and roots branched off, their bundle-sheaths being continuous and the tracheary tissue connected.

The stalks of the first three leaves are provided with a single axial bundle; but in the fourth, as in the mature leaf, there are two, one on each side of the deep groove in the front of the stalk. These two bundles are separate nearly or quite to the base, the stem-bundle being deeply cleft at the point where they issue from it. They are nearly round when seen in cross-section, the tracheary tissue being arranged in a band consisting sometimes of a single row of spiral tracheids, only four or five in number, the arrangement recalling that found in the older roots. The rest of the bundle is made up of elongated cells with rather thick walls which appear to swell slightly in water. The whole is surrounded by a sheath.

The number of roots exceeds that of the leaves, there being six fully developed roots in a plant in which the fourth leaf was not fully grown, besides several that were not fully developed.

Section IV. The Leaf.

The leaves arise from single segments of the apical cell of the stem. The first indication of the young leaf is the elevation of the surface of the segment, the apical cell of the leaf being formed very early from one of the surface cells. A wall is formed in this cell inclined to its outer wall so as to meet one of the lateral walls. This is probably followed by a second wall inclined to the first, and meeting it so as to include a wedge-shaped cell, the apical cell of the leaf. From this time the growth of the leaf is dependent upon the further development of this apical cell, which divides by walls directed alternately right and left into two series of segments. The early growth of the apical cell is rapid, soon resulting in a flattened cone with a broad base, the side in contact with the stem being more flattened than the outer face, which grows more rapidly, so that the young frond soon begins to bend inward over the end of the stem. This inequality becomes more and more strongly marked as growth proceeds, finally causing the frond to be closely coiled as is well known in all ferns.

The leaf-stalk develops at first much more rapidly than the lamina, which remains very small, proportionately, until the latter part of the summer previous to its unfolding, when it undergoes a great increase in size; the unfolding of the leaf being little more than an

expansion of parts already formed, this process taking place with extreme rapidity in strong contrast to the extraordinarily slow development of the earlier stages of the leaf.

The apical cell of the leaf (Pl. 6, fig. 7) is wedge-shaped, differing, therefore, in appearance as seen from different directions. The segments are formed by walls parallel to the lateral faces. Each segment is first divided into two cells by a transverse wall; the main fibro-vascular bundles of the leaf being developed from the inner of the two cells, the mesophyll, and the epidermis from the outer. The outer cell is next further divided by a wall parallel to the primary wall, and these two cells by walls parallel to their outer surfaces, these outer cells constituting the marginal epidermis. In the older leaves these marginal cells, although increasing rapidly in breadth, undergo no further division, the rest of the epidermis arising from the cells lying within these by walls parallel to the surface of the leaf. In the very young leaf, before there is any differentiation of stalk and blade, the growing point is thicker and the marginal cells early undergo division by walls parallel to the surface of the leaf.

Longitudinal walls are formed in the inner cells so as to transform them into a cylindrical mass of cells, those in the center being narrower and forming the procambium, the others the young ground tissue and epidermis. In the blade, all of the structures developed from the central cells remain as the rachis, but in the petiole it is impossible to discriminate between the ground tissue and epidermis developed from these cells and those from the outer ones of the segments. The cells of the procambium (Pl. 6, fig. 7) soon become easily recognizable by their greater length and more transparent contents. In the lower part of the leaf two parts can be distinguished, separated by a mass of shorter cells and these can be traced to the stem-bundle with which they are united, one coming from each side of the foliar gap, or opening in the stem-bundle opposite the insertion of the leaf.

The differentiation into petiole and blade is caused by the lateral growth becoming more strongly marked in the latter, the cells dividing rapidly by walls perpendicular to the surface of the frond, this being very strongly marked in the older leaf.

As growth continues, the young ground-tissue of the petiole begins to show a division into two portions: the true fundamental tissue and the hypoderm. The cells forming the latter are much narrower than those of the former and contain less chlorophyll, so that they are easily distinguished from the parenchyma lying beneath them at an early stage. They have oblique end walls, and increase rapidly in length, the walls also increasing in thickness and finally becoming dark brown. When the hypodermal cells are completed they form a sort of fibrous tissue. Outside of the hypodermal cells there is a single layer of epidermal cells, differing from them in their greater transverse diameter, but being shorter, resembling in shape more nearly the inner ground tissue cells. On the older basal portion of the stipe, the epidermis, together with its appendages, hairs and scales, becomes dry and brown, forming with the hypoderma a sort of cortex protecting the inner soft parenchyma. No stomata are developed from the epidermis of the petiole or rachis.

By the time that the ground tissue becomes recognizable as such, the formation of vertical walls in its cells ceases, the subsequent increase in the number of cells being caused by transverse walls only, resulting in the formation of regular vertical rows of cells. In

the younger parts of the petiole these cells are often much broader than long, owing to the rapid division. They contain fine granular protoplasm and distinct chlorophyll granules which are most abundant in the center of the cell, surrounding the large round nucleus. The subsequent thickening of the petiole is brought about by the enlargement of these cells which ultimately also increase very much in length. As the cells enlarge, they lose the chlorophyll which seems to be gradually replaced by starch. Even when colored with chlorophyll, the action of iodine caused the chlorophyll bodies to turn a dark bluish color, while in the older cells, from which the chlorophyll has entirely disappeared, the characteristic blue color is produced in the granules, which seem now to have the whole of the chlorophyll replaced by starch, appearing, indeed, like ordinary starch grains. A similar, apparent transformation of the chlorophyll bodies into starch grains was observed in the prothallium.

The fibro-vascular bundles of the petiole are ribbon-like, the transverse section being several times longer than broad. Before any markings are evident on the walls of the tracheids, their position can be easily made out by the greater size and transparency of the procambium cells from which they are to be formed. These cells form a band running through the center of the bundle, and curving at the ends (seen in transverse section). The first tracheids are formed at the points of curvature on the inner side of the central band of cells. From these the formation continues, following the course of the band.. These first ones are short and marked reticulately with close coiled spirals. The secondary tracheids are mainly scalariform. As already noticed the cross-section of the bundle is much longer than broad, the proportion being about ten to one. It is very slightly curved and only about half as broad in the middle as at the ends; the outer end being the broader, and being also less obtuse. The bundle is surrounded by a bundle-sheath composed of small cells whose walls are colored brown. This is more plainly seen in the upper part of the petiole where the bundles are somewhat smaller. When the petiole becomes dry the cells of the bundle-sheath split through the middle, so that the bundle separates from the ground tissue. Lying inside of the bundle-sheath, and surrounding the tracheary tissue, are from six to eight rows of cells in the lower part of the petiole, a somewhat smaller number in the bundle of the more slender upper portion. These vary much in size, are of prismatic form with moderately thick colorless walls, and no intercellular spaces. In the lower part of the bundle these are filled with starch but in the upper parts are nearly destitute of granular contents. The central part of the bundle is occupied by the tracheary tissue, mainly composed of the large secondary scalariform tracheids. They are strongly angular, the walls between neighboring ones being straight. The division walls are very sharply defined and in the older bundles often assume a clear yellowish brown color. In the narrower part of the bundle they form a central band of varying width, the tracheids also differing a good deal in diameter: but in the enlarged ends of the section the band of tracheary tissue, instead of terminating at the end, is bent on itself forming often a double band. This is more strongly marked in the outer end than the inner. The space between the two bands of tracheids at the ends of the bundle is filled with cells much like those that lie just outside them, but in the larger end they are somewhat smaller. In some places small cells lie between the tracheids, which in the parts of the petiole that survives the winter become filled with

starch. Among the tracheids near the ends of the bundle, there may sometimes be detected a group of smaller and more rounded ones,—the primary tracheids.

(Pl. 6, fig. 9. Inner end of a transverse section of the bundle of the petiole: *xy*, tracheary tissue; *ph*, phloem; *sh*, bundle-sheath. The band of tracheary tissue is not as strongly curved as usual.)

The first leaf developed from the end of a stolon shows striking embryonic characters, the whole leaf resembling in many respects the early ones of the germ-plant. The groove in the front of the petiole is not so strongly marked as in the later leaves, the petiole being nearly cylindrical; the hypoderm is reduced to form two to three rows of cells, and these are not so well differentiated as in the later leaves. The fibro-vascular bundles differ much, resembling almost exactly those of the third and fourth leaves of the germ-plant, being oval in section instead of elongated, and the elements of the bundle are less perfect than in the later leaves.

As is the case in the early leaves, the two bundles of the petiole in the mature leaves of the plant unite in the rachis into a single bundle, by a straight band of tissue forming so as to connect their inner edges. The bundle shows in its earlier stages four points at which the formation of tracheary tissue begins, corresponding to the same points in the separate bundles lower down. A cross-section of such a bundle, especially when treated with potash, shows clearly the position of the different elements of the bundle while still incomplete. The central procambium cells, from which the tracheary tissue is to form, become much clearer than the outer ones, and are seen to be, for the most part, larger. The primary tracheids appear almost simultaneously at the four points mentioned, and are easily recognized by their thickened walls.

Following these a number of small tracheids are formed around the border of the central mass of procambium, the development proceeding thence toward the center. As in the bundles of the petiole, the bulk of the tissue lying between the tracheids and the bundle sheath undergoes little further change, the sieve tissue being even less perfectly developed than in those parts. The development of the pinnae begins with the formation of segments by the apical cell of the leaf, after the blade becomes differentiated. Each segment gives rise to a pinna, which in turn becomes deeply pinnatifid. The formation of the pinna begins by the marginal cells of the segment growing more rapidly than those lying within them, thus causing the outer parts of the segment to project. These marginal cells multiply rapidly by longitudinal walls which repeatedly bisect them. Frequently, by one of the marginal cells in the middle of the young pinna becoming divided by an oblique instead of vertical wall, a triangular marginal cell is formed which becomes the apical cell of the pinna and divides in the same way as the apical cell of the leaf. On account of the difference in age of the segments from which they arise the pinnae are not opposite, but alternate. Whether or not an apical cell is always formed in each pinna is questionable; at any rate it cannot always be detected in the pinna when first formed. Sooner or later it is obliterated, in the same way as that of the prothallium, by a transverse wall, which is followed by a second wall at right angles to the first, the two marginal cells thus formed acting from this time on in all respects like the others.

In cases where an apical cell is formed in the pinna, the segment divides, as in the apex of the frond, into two cells, an outer and an inner, the latter forming the midrib or

secondary rachis, the former the mesophyll and epidermis, as well as the veins. Each outer cell divides into two by a wall parallel to the primary wall, and these in turn divide farther into an inner and outer cell, as was the case with the original segment (Pl. 6, fig. 7). A single row of marginal cells is thus formed about each lobe of the pinna, which continues to undergo the same divisions. The lobes of the pinna arise from it in precisely the same way that the pinnae are formed from the frond.

The cells lying immediately within the marginal cells divide by walls parallel to the surface of the leaf, so that a flat mass of cells is formed of which the outer layers are prismatic, forming the young epidermis, the inner ones polyhedral constituting the mesophyll. Up to this point the cells of the young lobes resemble each other, all containing finely granular, colorless protoplasm and having a large nucleus.

The cells of the young secondary rachis divide also by walls parallel to the surface of the leaf so as to separate them into a central cylinder, which is transformed by longitudinal walls into the procambium of the bundle, and the overlying ground-tissue and epidermis. The central cells of the young lobes become also divided by a series of longitudinal walls into a mass of narrow procambium cells running nearly to the tip of the lobe. The lateral veins are formed in acropetal succession, but do not begin to form until the lobe has reached some size. If the lobe has a definite apical cell, each lateral vein probably corresponds to each segment cut off from it; but when there is no apical cell, as is much more frequently the case, it is impossible to trace them back to a single cell. They arise from rows of cells in the young mesophyll extending from the midrib to the margin. These cells become divided by longitudinal walls so as to form the procambium of the young vein. The end of the midrib sometimes forks, so that there here remains a trace of the dichotomous branching of the veins of the earliest leaves. Cases where several veins appear to arise by dichotomy are sometimes met with, but these are exceptional, and probably never occur in fully developed fronds.

The formation of the young epidermis, ground tissue and procambium, is completed the year before the fronds unroll, and in the stalk the bundles develop a considerable part of the tracheary tissue; but it is not until the fronds begin to unfold that the different tissues become fully developed: and after this begins the process is a very rapid one.

The young epidermal cells increase very much laterally but with little increase in depth, so that they become tabular with extremely irregular sinuous outlines (Pl. 6, figs. 10–14). The mesophyll, which is at first composed of polyhedral cells with no intercellular spaces, becomes very loose by the formation of intercellular spaces arising from the unequal growth, and separation of the cells. The fibro-vascular bundles develop their different tissues now, stomata are found in the epidermis of the lower surface of the frond, the frond becoming in the meantime completely uncoiled, and the leaf is complete.

The formation of a stoma is preceded by the cutting off of a preliminary cell (Pl. 6, fig. 12), from which the mother-cell of the stoma is subsequently formed. This first wall is V-shaped, or nearly semicircular, and is soon followed by a similar but smaller one nearly parallel to it (fig. 10). The cell cut off by this second wall is the mother-cell of the stoma (fig. 10 *y*). The protoplasm in this cell is more dense than in the surrounding cells, the nucleus is well-marked, but the chlorophyll-granules, which are very definite in the ordinary epidermal cells, are almost wanting, or at least, very poorly defined.

A vertical section of the mother-cell at this time shows that it is somewhat elevated above the surrounding cells, and is also somewhat deeper. The mother-cell is first divided by a longitudinal wall, parallel to the axis of the lobe of the pinna, the nucleus showing evident signs of division before any wall can be detected. By the time that the division wall is complete, the stoma has assumed nearly the oval form of its completed condition, but the space between the guard-cells is wanting. This is formed by the division walls splitting through the middle. Vertical sections show that the air-space beneath the young stoma is small, but as the leaf grows, the space rapidly enlarges and finally reaches considerable size. In the meantime, the walls around the opening of the stoma become thickened, and the whole stoma enlarges. The chlorophyll-granules, which are indistinct in the young stoma, increase rapidly in size and number, and fill up nearly the whole of the guard-cells. Those in the mature stoma are elongated-kidney-form, but the ends are only slightly rounded, so that the whole stoma is almost perfectly elliptical in outline. The accessory cell, which at first had a smooth outline, acquires the sinuous outline of the other epidermal cells, and can only be distinguished from them by its position.

There are produced from the surface cells of the young leaf great numbers of hairs. In the youngest leaves they are mostly glandular, the terminal cell being much enlarged and pear-shaped, and filled with a densely granular but colorless mucilaginous secretion which is somewhat troublesome in the study of the young leaf. Such glandular hairs can be traced up to within a very short distance of the tip of the leaf, before any of the tissues are clearly differentiated. On the older parts of the leaf, when the epidermal cells have assumed their characteristic form, but before they are full grown, both simple and glandular hairs are developed, but the latter differ from those just described in regard to the contents of the terminal cell, the contents being dark brown and apparently resinous, instead of colorless mucilage. When the leaf is unfolding, but not fully grown, these glandular hairs are so numerous as to give a rusty appearance to the petiole and lower surface of the leaf.

Besides the hairs, there are formed upon the basal parts of the petiole of the young leaves, and also upon the growing point of the stem, large numbers of scales, whose first formed cells elongate rapidly, no longitudinal walls being formed in the extreme end ones, so that the scale, which is broad at the base, tapers to a point consisting of a single cell, or more commonly a row of two or three, which become extraordinarily elongated. The terminal cell develops a gland filled with mucilage, but the growth of the scale continues long after the gland has been destroyed, and the cells supporting it dried up. The scale grows at the base which becomes broadly cordate, the cells there undergoing rapid division. The upper cells gradually die and lose their contents, becoming dry and brown, and finally the whole scale dries up, so that they form a thick brown chaff clothing the bases of the petioles.

In the young plant the leaves have the one-third arrangement, but in the older ones they are so crowded that it is somewhat difficult to make out their arrangement; but with care it may be seen that it is the same as described by Hofmeister for *Aspidium Filix-mas*, *A. spinulosum*, and *Asplenium Filix-fœmina*, the five-thirteenth arrangement. That is, the angle of divergence is five-thirteenths, and the fourteenth leaf stands above

the first, etc. On examining a plant at the end of the season, it will be found that not only are the leaves for the following year plainly evident, but also those of the year after. In a small plant that had only unfolded four leaves the previous summer, there were easily seen fourteen young leaves in various stages of development, and this simply by drawing back the outside ones. The outermost ones have the broad base of the petiole almost completely formed in the autumn, the frond being very small and closely coiled. It generally happens that some of these outer ones do not develop the frond at all. The inner ones rapidly become smaller, and it is not easy to tell just how many are to develop the next season. Indeed it sometimes happens that if the first set of fronds is prematurely destroyed, others may develop later that ordinarily would not have done so until the following season.

Each year there is found a circle of fronds which grow nearly upright, but the tips bend slightly back, so that the group has the form of a deep vase, giving the plant an extremely elegant appearance. These fronds are all sterile and are ordinarily about one metre in height, but may reach twice that, or even more. The frond is pinnate, the pinnae being deeply pinnatifid. It increases in breadth from the apex to a point below the middle when it becomes narrower tapering thence to the stipe, the lowest pinnae being extremely reduced. The lobes of the pinnae are entire except in the first aërial leaves that are produced by the stolons, in which the pinnae are not so crowded and the lobes broader in proportion and slightly dentate, recalling somewhat the earlier leaves of the germ-plant. The lobes of the pinnae of the adult leaf are broadly lanceolate, the pinna being cleft almost to its rachis, and each lobe is provided with a mid-rib, which usually forks at the apex and is provided on each side with from eight to ten simple veins which extend to the margin. The hairs developed upon the young frond disappear, leaving it almost completely glabrous.

Specimens brought into the house in April, after remaining stationary for about two weeks, began to unfold their leaves and, in measuring one week after, it was found that they had reached a height of sixteen inches, so that it can be readily seen that the complete unfolding of the leaf would take but a very few weeks.

The fertile fronds begin to unfold about two months later, but their growth is slower, the development of sporangia beginning very early and new ones forming up to the time that the leaf is full grown. The fertile fronds are very much smaller than the sterile, and grow rigidly upright among them, from two to six being ordinarily produced by each plant annually. They seldom grow more than one-half metre in height, and the pinnae are very much contracted, probably on account of the great draft made upon the frond from the excessive production of sporangia. When mature they are dark, almost blackish green in color, and the margins of the pinnae so strongly revolute as entirely to conceal the sporangia. The segments are scarcely separated in the young frond, but there are constrictions between them so that the pinnae have a beaded appearance. Each segment (Pl. 7, fig. 28) has but five veins, a mid-vein and four lateral ones, none of which run completely to the margin. The upper half of the lobe is composed of but one layer of cells, acting as an indusium. A transverse section of the young pinna (Pl. 7, fig. 10) shows that not only is the margin strongly revolute, but that it is folded on itself once, and sometimes twice. Unlike the sterile leaves which decay in the autumn, the fertile

fronds, although becoming brown and dry, remain standing through the winter, owing to the stout and firm stalk. In these dried fronds the pinnae often flatten out, and their segments become separated so as to facilitate the dispersion of the spores.

Section V. The Stem.

The growing point of the stem is completely concealed by the young leaves which meet over it, and in addition to this the numerous glandular scales interfere seriously with its study. Unless care is taken, it is an easy matter to confound one of the young leaves with the apex of the stem, for when seen from the side, being conical in form and having a definite apical cell, the resemblance is quite marked. The apex of the stem itself (Pl. 7, fig. 1), when a section passes directly through it, is seen to be much broader than the young leaves. On account of the dense contents of the cells, the primary meristem is difficult to study unless some method of clearing the tissues is employed. The ordinary potassium hydrate solution will usually answer, neutralizing when necessary with acetic acid.

The apical cell (fig. 1, *a*), whether seen from the side or from above, appears triangular, being, in fact, a tetrahedron. Segments are cut off from the lateral faces in regular succession, the direction of the spiral being usually from left to right. Each segment is first divided into two cells by a longitudinal wall at right angles to the lateral wall of the apical cell. Each of these cells is next divided by a transverse wall into an inner and outer cell (fig. 1), and subsequently each outer cell is divided into two by a longitudinal wall parallel to the lateral wall of the apical cell. Each original segment is thus divided into six cells, two inner and four outer ones. From the inner cells the plerome cylinder is formed; from the outer the periblem and the dermatogen. This latter (figs. 1, 2, *x*) results from a series of walls formed in the outer cells parallel to their outer walls.

The inner cells of the segments increase rapidly, the divisions being mostly longitudinal, so that the lateral growth of the segment is much greater than the longitudinal, and the diameter of the stem is rapidly enlarged, so that the end has the form of a cone with broad base and obtusely angular apex.

The outer cells are at first narrow, as seen from the side, being really tabular; later, losing this by divisions perpendicular to the broader faces of the cells.

The mass of meristem, resulting from these divisions, is composed of small, polyhedral cells of about equal transverse and longitudinal diameters, filled with densely granular protoplasm and provided with a distinct nucleus. Very early, a careful examination shows a distinction between the cells developed from the inner cells of the segments and the outer ones. The former are rather longer and their length somewhat greater in proportion to their breadth. These inner cells, which form the plerome in the stem of the mature plant, now become separated into two parts: an inner one which retains for some time its original character and an outer layer whose cells become divided by a series of longitudinal walls into a mass of long, narrow procambium cells. This procambium cylinder is not continuous, but is interrupted at intervals corresponding to the position of the leaves, by spaces in which the cells resemble those of the inner part of the plerome cylinder. These are the foliar gaps, and through them the inner part of the plerome,

which forms the medullary parenchyma of the stem, is joined to the periblem from which the cortical parenchyma and hypoderm arise. The procambium has thus the form of a hollow cylinder, with openings at regular intervals, and, as the procambium develops into the elements of the complete bundle, the whole assumes the form of a cylindrical net, apparently formed by the union of separate bundles, but being strictly a single bundle.

Shortly after the procambium begins to form, the central part of the plerome begins to show the formation of the cavities that characterize the central parts of the stem. At certain points the cells become longer and their contents less dense, so that the places appear more transparent than the surrounding tissue. The cells cease to divide, or at least do so more slowly than the surrounding ones. By the rapid growth of the surrounding tissue and the consequent widening of the stem, certain of these cells are torn apart, leaving intercellular spaces that become rapidly larger as the stem widens. These spaces are bounded by loosely arranged cells whose free ends are rounded and with nearly colorless contents containing a few definite granules and a distinct nucleus. From these cells trichomes of different forms are developed. These may be in the form of simple hairs or scales of considerable size. Sometimes, but not very often, they may be tipped with a pear-shaped glandular cell, filled with dense granular mucilage.

The mass of trichomes filling up the cavity now dries up, and the cells bordering them have their walls somewhat thickened and changed to a brown color. Thus, there are formed large air spaces distributed through the stem. Very often these communicate with the spaces between the bases of the leaf-stalks and the stem, by the destruction of the intermediate tissue, brought about in the same way as the formation of the cavities themselves, the cavities thus being brought into communication with the external air. The communication between the inner and outer cavities takes place through the foliar gaps. Finally, the cells about the cavity acquire thicker walls, which are at first yellow in color, but finally dark brown, forming an imperfect sclerenchyma.

The remainder of the medulla develops into a mass of parenchyma, densely filled with starch. The walls gradually become thicker and develop simple pits.

The periblem, which has rather longer cells, separates into two portions, but not until a later period. Its cells become longer and finally several of the outer layer become still longer, their walls also becoming thicker and the contents less opaque. These constitute the hypoderm, and finally become very sharply separated from the underlying cortical parenchyma. Their lateral walls are somewhat uneven, and all the walls swell up more strongly on the application of potash than those of the parenchyma. The walls of the hypodermal cells next assume a yellow color, which becomes later much darker and the wall finally develops pits which extend to the intercellular lamella which is very clearly defined and appears darker than the rest of the wall. This sclerenchyma, although well-developed, does not attain as perfect a form as is found in some other ferns.

The epidermis of the stem never reaches any degree of perfection, as only a very small part of the surface of the stem is uncovered, and none of it in direct contact with the air. Whatever epidermis there is soon dries up and becomes brown like that of the root.

On account of the foliar gaps, as well as the attachment of the bundles from the leaves, roots and stolons, the separate parts of the stem-bundles are usually very irregular and run, for short distances only, in a vertical direction.

The first permanent tissue to appear in the bundle is composed of small tracheids near the foci of the bundle which is elliptical in section. Those at one focus, and these appear rather earlier than at the other, are spiral or reticulate, although they are often scarcely to be distinguished from the later scalariform ones. Those at the other focus are not to be distinguished in appearance from the other tracheids, except that they are smaller than most of them. In the completed bundle they are indistinguishable.

The large scalariform tracheids, making up the bulk of the xylem, are larger than are found elsewhere in the plant. The cells from which they are formed are broader than those of the rest of the procambium, but are not very long. Their ends are at first simply oblique, but as growth continues, they become slightly curved, and each cell somewhat spindle-shaped, and strongly prismatic from the pressure of the neighboring cells. In the earlier stages, before any traces of the markings on the walls are distinguishable, the cells contain abundant protoplasm, in which are embedded numerous coarse granules, and a moderately large oval nucleus. Previous to the formation of the scalariform markings, the contents become somewhat clearer, owing to a partial disappearance of the granules. The markings first appear as faint transverse ridges on the walls that are in contact with another tracheid, corresponding ridges appearing each side of the wall. These soon become thick enough to show that they end at the angles where the tracheids meet, and enclose long, narrow, transverse pits, or spaces where the wall is not thickened. This process begins with the cells lying next the primary tracheids, but after the first begin to form, the remainder of the xylem develops with great rapidity, and almost simultaneously. The ridges separating the pits soon begin to show an inequality in the thickening. At points where they touch the division wall they increase but little in breadth after they are first formed, but as they increase vertically in thickness, they also increase in breadth, until at a point about half-way up they reach a breadth of about twice that at the base. From this point they narrow again, so that a transverse section of one of these bars is nearly rhomboidal. In this way a pit is formed broader at the bottom than at the top, or funnel-form, the broad end of the funnel being in contact with the wall separating the tracheid from its neighbor.

The development of the sieve-tube begins shortly after that of the large scalariform tracheids, and in some respects resembles it. The cells of the procambium, from which the sieve-tubes originate, are uniform in diameter and have squarer ends than the young tracheids, so that the separate elements of the sieve-tubes are more nearly cylindrical than the tracheids. They occupy an irregular area at each end of the bundle, and can be best seen in a section passing through the major axis of the elliptical bundle. Their contents are colorless and more finely granular than those from which the tracheids arise, and the nucleus is not so readily seen. The sieve-discs are more abundant in the lateral walls, and are developed almost simultaneously in all.

Faint, transverse ridges appear upon the lateral walls, much as in the young scalariform tracheids, but they are broader and not so close together, so that the spaces or pits enclosed by them are larger. The bars are frequently somewhat oblique, so that they

anastomose to some extent, making the distribution of the pits or young sieve-discs irregular. As they become older these thickened bands become more strongly marked, but the thickenings are uniform, so that the sieve-discs do not present a bordered appearance, although sometimes, owing apparently to a slight rounding of the outer surface of the thickened ridges, the outline of the sieve-disc is not as clearly defined as when the breadth of the band is absolutely uniform. Corresponding thickenings are formed on the opposite sides of the wall, and probably fine pores are developed in the lateral sieve-plates, but this could not be proved. In one case, an oblique wall, which separates the ends of two neighboring tubes, and was very strongly inclined, showed several very sharply defined pits, which appeared to penetrate the wall and thus to throw the cavities of the adjoining tubes into communication. The complete tubes are seldom perfectly straight, the lateral walls being curved, especially at points where the bundle is bent.

The remaining procambium undergoes little change, retaining the form of thin-walled parenchyma occupying the spaces between the tracheids and outside of the sieve-tubes. Two or three rows remain, forming a ring inside the bundle-sheath which differs from them mainly in the walls of its cells being brown, and the cells flattened laterally. As the tracheids become old, their walls often become yellow.

The complete rhizome is comparatively slender, being only about two centimetres in diameter; but, on account of the persistent bases of the petioles, it appears much thicker, often ten centimetres or more. These overlapping leaf-bases give it a bulb-like appearance, as those of several years remain attached. The rhizome is either upright or inclined at the base, and may reach a length of twenty to thirty centimetres, or even more in old plants. The oblanceolate leaf-bases are about four centimetres long by one centimetre in breadth and one-half centimetre thick. They project above the young leaves and thus protect them before they are ready to unfold.

With a little care, portions of the net-like, fibro-vascular cylinder of the stem can be separated, as like the bundles of the leaves, it is sharply differentiated and readily comes away from the surrounding parenchyma. The bundles are firm and woody in texture and the meshes of the net nearly rhombic, about one-half centimetre in length. From the lower angle of each mesh, two bundles, one on each side, are sent to the leaf, there being a leaf opposite each foliar gap.

Below the leaf-bundles, or sometimes connected with them, the bundles of the roots join the stem-bundle, there being usually in the older parts several roots at the base of each leaf. There are no bundles running through the medulla.

Connected with the rhizome there are usually to be found numerous long and slender stolons, which under favorable circumstances appear above ground and develop a crown of leaves.

They arise near the bases of the leaves, and in almost any plant numbers may be met with ranging in size from one-half centimetre in length to twenty or thirty centimetres or more, and apparently remaining dormant for an indefinite period, as the number of undeveloped ones far exceeds those which have grown to the surface of the ground. A section through the base shows a single axial bundle which is connected with the bundle of the rhizome close to the base of a leaf. The stem of the stolon remains for a long time slender, and the narrow scale-leaves, which show no division into stalk and blade

are remote from each other, being separated by about one-third of the circumference of the stem, but owing to the fact that the stem is somewhat twisted, it is not easy to determine whether or not the fourth leaf stands directly above the first. When quite small, the stolons are crowded between the base of the leaf and the rhizome, so that they are flattened, and the angle of divergence of the earliest leaves appears to be one-half. The surface, both of the stem and scale-leaves, is smooth and of a dark, reddish brown color. At the tip, the younger parts are greenish, chlorophyll apparently being formed, even when the stolon is completely underground, and of course shut off from the influence of light.

The stolon, when first formed, is very slender, but a short distance above its insertion it suddenly enlarges, so that it assumes a club-shape. Up to this point no leaves have been developed, and a section through the enlarged apex shows that this enlargement is due in part to the formation of the first leaves. The apex is nearly flat and much broadened on account of the increased lateral growth. It consists of a mass of small cells developed from the apical cell, and these soon become separated into plerome and periblem, the dermatogen not being readily made out in the very young stolon. The plerome in the basal parts is a simple cylinder of uniform size, but just below the first leaves, it widens suddenly, and divides later into two masses of procambium cells, separated by a mass of shorter ones. This division of the plerome cylinder takes place about the time that the first tracheary tissue is formed in the lower part of the stolon. As the permanent tissues develop in the bundle, this central mass of short cells forms the medullary parenchyma which communicates with the cortical parenchyma, by the foliar gaps, as in the main rhizome. The separation of the medullary parenchyma from the procambium begins before the bundle divides, thus occupying the center of the perfectly cylindrical bundle, and surrounded by an uninterrupted mass of procambium, which ultimately forms the hollow axial bundle that traverses the stolon for a short distance from its base.

The apex of the older stolons is more conical, and the apical cell has the form of that of the mature stem: — a tetrahedron with nearly equal lateral faces from which segments are cut off in the same way. The mass of meristem cells developed from them can soon be separated, as in the younger stolon, into plerome and periblem, the former soon showing the central shorter cells and the outer elongated procambium cells, the procambium cylinder being interrupted by masses of shorter cells like those of the medulla, and connecting the latter with the cell of the periblem. These spaces, the foliar gaps, become later much elongated on account of the great length of the internodes, but there are but three of them in a single cycle, corresponding to the primitive one-third arrangement of the leaves like that of the young germ plant, each leaf probably representing a segment of the apical cell.

The first tissue to assume the permanent form is the cortical parenchyma which in the slow-growing younger stolons can be traced up nearly to the apex. The cells are irregularly polyhedral in form, and distinct pits are early developed upon their walls. They contain small starch grains in considerable quantities, but no other conspicuous contents. No definite hypoderm is formed in the young stolons, but one or two layers of the outer cells acquire, very early, dark brown walls. The ground tissue is almost complete and its cells full grown, before any permanent tissue is developed in the fibro-vascular bundle. The procambium cells are long and narrow with oblique ends, and filled with granular,

but colorless protoplasm. The first to be transformed into permanent tissue are situated nearly in the center of the axial bundle in the base of the stolon. A number of the cells of the procambium develop narrow transverse pits upon their walls, thus forming a mass of short scalariform tracheids, from which the formation of tracheary tissue proceeds, following lines nearly parallel with the circumference of the bundle. Sometimes a complete circle is formed, sometimes they extend hardly more than half-way round. The secondary tracheids are broader, but not very long, and often with the lateral walls somewhat sinuous. Their walls develop perfect scalariform markings.

In the two bundles found higher up, formed by the division of the plerome cylinder into two unequal parts, much the same process takes place, the tracheary tissue beginning with small scalariform tracheids near the center of the bundle, or sometimes toward one side, and the subsequent ones are formed within, and also towards the sides.

In the earlier formed parts of the stolon the bundle undergoes little further change except that a sheath is formed about it, and it is difficult to say whether some of the cells represent the parenchyma or sieve-tissue of the more perfect bundle of the main stem.

Just before the stolon appears above ground, the internodes become very much shorter and the leaves, instead of being scale-like, assume the character of foliage leaves. The young leaves are crowded together so that the end of the stolon is much thicker than its subterranean portions. In the cases observed, there were usually two fronds developed above ground almost simultaneously, differing so much in appearance from the later ones that, were their origin unknown, they would not be recognized as belonging to the same species as the mature fronds. Their pinnae are much fewer, and less crowded; the lobes less deeply cut, and their margins somewhat crenate; the whole frond looking much like the earlier ones of the germ-plant. Sometimes these appear to be the only leaves developed the first season, but in others later ones were formed, which, though small, had all the characteristics of the perfect leaf. The plant is now, in everything but size, complete, and soon becomes severed from the parent plant by the decay of the base of the stolon, thus becoming independent.

In one case a young branch was observed upon a stolon that had recently appeared above ground; this appeared to be developed, not as an adventitious bud, as in the case of the stolons themselves, but in the same way as a leaf, seeming to have taken the place of one of them. Its fibro-vascular bundle was continuous with that of the stem, which was still undeveloped, none of the permanent tissues having yet appeared. The end of this branch had developed the rudiments of two leaves and was in all respects like the end of any stem. Both stem and leaves had already developed scales.

Section VI. The Root.

The roots are produced in abundance from and near the bases of the older leaf-stalks. Each primary root develops numerous secondary ones that are arranged in two ranks in opposite sides of the main one. In all but the youngest parts the root is covered with a sort of dark brown cortex, formed by the remains of the epidermis and the underlying cells.

The development of the main roots can best be seen on the earlier aërial leaves of a stolon, as it is less difficult to make satisfactory sections than in the thicker mature stems. They arise from the bundle-sheath of the stem-bundle before any permanent tissue is de-

veloped, a short distance below the insertion of the leaf. Later ones arise from the broad bases of the stipe, and such have their bundles connected with one of the leaf-bundles. The primary roots grow rapidly, soon breaking through the overlying tissue; this taking place about the time that the tracheary tissue begins to form in the bundle with which they are connected.

The growth of the root from the apical cell is best studied in roots from an actively growing plant, that is, in spring or early summer. Such roots are light colored at their growing points, and their longitudinal sections through the tip will usually show very satisfactorily the formation of the tissues. As seen from the side, the apical cell (Pl. 7, fig. 6, *a*) is nearly triangular in outline, and in large roots is of very large size and easily seen. In smaller ones, where growth is slow, it is smaller and not so readily detected, although its form is often more regular, as in actively growing roots, the growth of the younger segments cut off from it often causes the sides to be bent (fig. 6). The outer wall, which is usually broader than the lateral ones, is slightly convex. If a series of transverse sections is made near the end of the root, one of them may pass through the apical cell, which viewed from above appears also triangular (fig. 7), but the sides are unequal. This shows that the cell, like the apical cell of the stem, is tetrahedral in form, the base being directed toward the apex of the root. The apical cell contains a large globular nucleus and the protoplasm is granular but not sufficiently so to render the cell opaque, in which respect less difficulty is experienced than in the other parts of the plant.

The succession of the segments is very regular and can be traced with comparatively little trouble. Each series consists of four cells, three from the lateral faces, which give rise to the tissues of the root itself, and one from the outer face, the cap-cell, from which the cells of the root-cap are formed. Each segment is at first a tabular cell, with the broad faces triangular. In order to see the first division in each of the segments, transverse sections through the young segments are necessary (Pl. 7, fig. 7). If this is done it will be found that each segment is first divided into two cells by a radial wall (sextant wall). The sextant wall does not divide the segment into quite equal parts, as its inner edge is in contact with one of the lateral walls of the segment some distance above its inner angle (fig. 8). Each of the two parts of the segment is next divided by a tangential wall into two cells, an inner and an outer one (fig. 6). From the series of inner cells the central fibro-vascular bundle is derived; from the outer, the ground tissue and cortex, each outer cell of the segment dividing into two by a second tangential wall, from the outer of which the cortex is formed, from the inner the ground-tissue. Almost simultaneously with these divisions, others are formed parallel to the sextant walls, but for some time no walls are formed parallel to the wall by which the segment was cut off from the apical cell, and consequently each segment remains in the form of a single layer of cells, until about two full rows of segments have been cut off. As a result of the divisions of the segments being thus formed, the depth of the segments increases but little as compared with the lateral growth, and the end of the root is nearly flat.

The mass of meristem arising from the division of the segments, becomes very soon differentiated into three concentric masses. The central one of plerome is cylindrical forming ultimately the fibro-vascular bundle, and, as before stated, arises from the inner cells of the segments. Its cells become rapidly transformed, by longitudinal walls, into

a mass of narrow cells, the procambium (Pl. 7, fig. 6, *z*). Lying immediately around the plerome cylinder is a layer several cells in thickness, whose cells are broader than those of the plerome and which can be traced back to the inner of the two cells, formed by the second division of the semi-segments. This is the periblem (fig. 6, *y*) giving rise to a ground tissue. Outside is the third layer, or dermatogen, arising from the outer cells of the segments and forming the epidermis and cortical parenchyma, or such hypoderma as may be present. The limits of these three primary tissue-masses can be traced back to the youngest segments, as there is little displacement of the original cell walls through subsequent growth, this being also true in cross-sections (fig. 8), the sextant walls being perceptible in sections made some distance from the apex, and in such sections the successive divisions of the plerome cells can best be studied. Each of the original plerome cells is first divided by a tangential wall into an inner and an outer cell, the latter being again quickly divided by a radial wall. The inner cell seems to have the same process repeated again, but beyond this the divisions do not appear to follow any regular order. In the periblem, no definite order could be detected in regard to the formation of the division walls, but in the dermatogen cells of the seventh or eighth segment from the apical cell walls are formed almost simultaneously, at right angles to the longer axis of the cells, so that the segment, seen from the surface, shows a double row of cells of nearly equal size. As a result of this division, the cells of the dermatogen are shorter than those of either plerome or periblem.

All of the meristem cells have large nuclei and granular, but almost perfectly colorless, contents, and usually sufficiently transparent to make their study an easy matter.

The first division in the cap-cell is nearly parallel to one of its lateral walls, and the cell seen from above appears divided into two cells, one of which is triangular, the other quadrilateral. The segment soon loses its triangular form, becoming nearly circular and a second wall is formed perpendicular to the first, thus dividing the segment into four nearly equal cells, arranged like the quadrants of a circle. These subsequently become further divided by both radial and tangential walls, but not by walls parallel to the outer wall of the apical cell, so that they retain permanently the condition of single layers of cells.

The wall by which the cap-cell is first separated from the apical cell is not perfectly parallel to the outer wall, but is somewhat flatter, so that seen at first the segments are somewhat higher in the middle than at the sides. As it develops, the cells in the center elongate more rapidly than those at the sides so that this inequality becomes more and more marked as the segments become older, and the tip of the root finally becomes decidedly conical, although the end of the root itself is nearly flat.

In the rapidly growing root, only the outer cells of the root-cap are brown, but in the more slowly-growing ones, all but those near the apical cell have their walls somewhat thickened and brown, and the cell-contents dried up.

The differentiation of the parts of the fibro-vascular bundle from the plerome does not begin until that of the ground tissue, hypoderma and epidermis is far advanced. At this time, the plerome consists of a mass of narrow procambium cells, those toward the circumference being somewhat shorter and with less oblique ends; those of the central ones being generally strongly oblique, so that the cells derived from them have sharply pointed ends, fitting closely together with no intercellular spaces. The cells increase greatly

both in length and breadth, reaching nearly their full size before they begin to show any differentiation. The cells are filled with colorless protoplasm, almost destitute of granules, and with a large and distinct nucleus, especially in the outer ones. The procambium cylinder is broader in one direction, so that the section is elliptical. The first permanent tissue is formed near the foci of the elliptical bundle, there being formed almost simultaneously at both foci a single row of narrow, spiral tracheids. These are long with pointed ends, fitting closely together. At first the spiral markings are very fine and close, but with further growth they separate somewhat and also become thicker. A long row of them is completed before any trace of other tracheary tissue is to be found. Around these primary tracheids are next formed two or three rows of similar ones, and from the formation of tracheary tissue proceeds toward the center of the bundle.

An examination of the tissues of the complete root show that the tissues are less fully developed than in the aërial parts of the plant or the rhizome. The outer cells are dry and broken, and from them are seen growing the remains of numerous root-hairs, which, except in the younger parts, are also dry and brown.

The lateral roots arise in strictly acropetal succession and are arranged in two rows on opposite sides of the larger roots. Their formation begins before the tissues of the bundle of the main root are differentiated. Just before the primary tracheids are formed in the latter, the apical cell of the secondary root is formed from one of the cells of the bundle-sheath. The exact method of the formation of the apical cell was not traced, but it seemed to arise from the formation of three walls in one of the cells of the bundle-sheath so placed, as to include, together with the outer wall of the cell, a tetrahedral cell. This at once begins to grow and divide in the same way as the apical cell of the main root, and the young root breaks through the overlying tissues of the main root about the time that the first scalariform tracheids of the latter are complete. Its tissues develop in the same way as those of the main root, and the tracheids in the lower part are in direct contact with its primary tracheids. The major axis of the bundle of the secondary root is at right angles to that of the main root.

The bundles of the secondary are joined to that of the main root, the secondary root being at right angles to the latter, a line passing through the center of the bundle being coincident with the plane traversing the major axis of the main bundle. The bundle-sheaths are continuous and the tracheary tissue of the base of the secondary root ends abruptly against that of the main root, the tracheids of the former being smaller than the adjacent ones of the main root, and bent and flattened at the points of contact. Owing to the distortion of these basal tracheids, the bundle is larger at the base than elsewhere. The other elements of the bundle are also bent so as to connect the corresponding parts of the two bundles. The structure of the lateral roots is essentially the same as that of the main root, but the section of the bundle is more nearly circular.

Section VII. The Sporangium.

The development of the sporangium begins while the fertile frond is still small, and in order to procure the youngest stages most satisfactorily, it is necessary to begin with them when the fronds are just beginning to unroll. The margins of the pinnae are so

strongly revolute (Pl. 7, fig. 10), that the whole lower surface of the lobes is completely covered, the margins acting as an indusium.

The young sorus (fig. 11) arises as a small prominence above a young vein, and is formed by a rapid growth of cells at and just below the surface. This prominence soon becomes hemispherical, and the formation of the sporangia begins. These arise as papillae from the superficial cells of the receptacle and are, therefore, morphologically, trichomes.

All the cells of the young receptacle are colorless, filled with fine granular protoplasm, and distinctly nucleated. The cell from which the sporangium is to arise (fig. 13, *m*) soon becomes slightly convex, dividing then by a wall parallel to the surface into two cells, an outer and an inner, the former (fig. 14) being the mother-cell of sporangium, the other taking no further part in the formation of the sporangium. Sometimes, but not usually, the original cell appears to undergo a preliminary division before the mother-cell of the sporangium is cut off. The mother-cell rapidly enlarges, assuming first a hemispherical form, and then elongating so as to become rather pear-shaped. After reaching this stage it is divided by a wall parallel to that by which the mother-cell was formed, into two cells, the lower of which forms the pedicel, the upper the capsule of the sporangium (fig. 15). In the earlier sporangia the upper cell undergoes several divisions before any more are formed in the lower one, but in those formed later, the pedicel lengthens rapidly in order to bring the young sporangium on a level with those previously formed, and it undergoes several divisions very early, so that on examining an older sorus, it is not at all uncommon to find very young sporangia in which the pedicel is many times longer than would be the case in those of the same age taken from one of the younger sori.

The first division in the capsule is nearly vertical, but usually slightly inclined, so that the resulting cells are not quite of equal size (fig. 16). Following this is a second wall inclined to the first at an angle of about 60°, and next a third, parallel to the outer wall of the capsule, and meeting both of those already formed (figs. 16-19). If a sporangium is now examined from above (fig. 19), it will be seen that both edges of the first wall are in contact with the outer wall of the capsule; that the second has one edge in contact with the first wall, and one with the outer wall of the capsule; while the third, which is nearly triangular in form, touches the wall of the capsule with its upper edge only, the other two being in contact respectively with the first and second. Finally a fourth wall is formed parallel to the upper surface of the capsule, but not touching its outer wall at any point, its three edges being in contact with the three walls just described (figs. 18–20). The capsule now consists of five cells, four parietal ones, tabular in form, and a central tetrahedral one, the *archesporium*. By the time that the capsule has reached this stage, the pedicel has usually undergone division by a longitudinal wall, into two unequal cells (fig. 20). The larger of these divides again by a second longitudinal wall, and the three cells thus formed become divided by a series of transverse walls, so that the pedicel when complete consists of three rows of cells. These are short at first, except in the later formed sporangia, but finally become about four times as long as broad (figs. 24, 26).

The archesporium now becomes divided by walls parallel to the first walls formed in it, and developed in the same order (fig. 21). These are the primary tapetal cells, and, while they are forming, the parietal cells undergo further divisions by walls perpendicu-

lar to the surface of the capsule, but directed in various directions (fig. 21). Walls are never formed in the parietal cells parallel to the surface of the capsule, so that the wall of the complete sporangium is a single layer of cells.

The tapetal cells very soon become also divided by walls perpendicular to their broader faces (figs. 21, 22), so that at this stage the central cell of the archesporium is surrounded by a double layer of cells. Somewhat later, about the time that the central cell becomes divided for the second time, the tapetal cells become further divided by walls parallel to the outer walls of the central cell, so that the tapetum is now composed of two layers of cells (fig. 23). These walls are not always perfectly parallel to the outer wall of the capsule, but frequently inclined more or less.

While these changes have been taking place, the sporangium has increased greatly in size, and become somewhat flattened laterally, this being much more strongly marked in the later ones which often do not fully develop.

A surface view of the young sporangium shows that the arrangement of the parietal cells is not the same in all parts. A row of cells running around the longest arc of the capsule has divided more rapidly by transverse walls than any of the other cells, resulting in the formation of a row of transversely elongated cells running all round the capsule (figs. 22, 24). As the sporangium increases in size these continue to divide in the same way until there are between thirty and forty of them. These are the cells of the annulus. The other parietal cells divide more slowly and by longitudinal as well as by transverse walls.

About the time that the annulus can first be distinguished, and just before the tapetum becomes two-layered, the inner cell of the archesporium begins to divide to form the spore mother-cells. The direction in which the first division takes place is not always the same, being in some cases nearly vertical, in others horizontal, but in either case more or less inclined (fig. 22). Following this a second wall is formed, nearly at right angles to the first, thus dividing each of the cells already formed into two (fig. 23). Almost simultaneously the two layers of the tapetum are completed.

The central cells, almost from the first, are distinguished from the outer cells by their more dense and highly refractive contents. They now undergo further division until the complete number, twelve, of the spore mother-cells is attained. The latter are colorless, but contain numerous fine granules, and each has a large and pretty evident nucleus. As soon as the full number is complete, the walls of the tapetal cells are absorbed and the mass of mother-cells, which are still connected, floats freely in the cavity of the sporangium which it does not nearly fill (fig. 24). The annulus has acquired nearly its full number of cells, and the whole sporangium its complete form, though still considerably smaller than when mature.

The spore mother-cells now become separate by the partial dissolution of their walls, and becoming rounded off float about in the cavity of the sporangium which they nearly fill, having increased very considerably in size after separating. Each spore mother-cell is at this stage globular, with a large, but not usually very distinct nucleus which is sometimes central in position, sometimes eccentrically placed. The protoplasm is somewhat less granular than before, areas of considerable size being frequently quite free from granules.

The first trace of division in the mother-cells is a change in the nucleus. This be-

comes larger and elongated and coarsely granular in appearance. In some cases observed at this stage, the nucleus was extraordinarily distinct. The nucleus increases greatly in size, but becomes much less distinct (fig. 25), and careful observation shows the formation of the nuclear spindle, but no satisfactory view of the nuclear disc could be obtained, although usually there was an evident line separating the two parts of the mother-cell, which at this stage has increased slightly in size and become somewhat oval in form. The two secondary nuclei are formed at the poles of the nuclear spindle and become, when complete, much like the primary nucleus. They very soon divide again, probably in the same way as the primary nucleus, resulting in the four nuclei of the young spores. Although there is a dividing line between the two masses of protoplasm into which the mother-cell first divides, no cell wall seems to be formed; but after the second division is complete, the young spores become separated by walls. The planes of division of the nuclei are at right angles, so that of the four resulting spores, two lie in one plane and two in another. After division is completed, the spores begin to lose the granular appearance they hitherto exhibited and become more transparent. They now separate, but remain sufficiently united to show which belong together and have become almost destitute of granular contents. They are kidney-shaped, slightly flattened on one side, but appear oval if seen from above. Each is provided with a very distinct nucleus, embedded in the protoplasm near the wall on the flattened side. The spores rapidly increase in size until they are about twice as large as when first formed, this increase being probably due to the using up of the material derived from the tapetal cells. Each spore has a distinct wall which is early partially differentiated into an inner and outer wall. A third coat, brown in color (the exospore), finally appears and attains considerable thickness. It becomes provided with a series of ridges or folds (fig. 27), but even when young is easily separated from the spore by slight friction. Before the exospore is formed, very fine granules are seen to appear, most abundantly in the vicinity of the nucleus. These rapidly enlarge and are seen to undergo division. About the time that the exospore begins to develop, some of them become tinged with chlorophyll, and continuing to form rapidly, the spore soon becomes densely crowded with them, so as almost to conceal the nucleus and render the whole spore almost perfectly opaque and dark green. The nucleus changes its position, moving toward the center of the spore, the exospore reaches its full thickness, and the spore is complete.

While the spores have been developing, during which time they have grown so as to fill the sporangium completely, the parietal cells of the sporangium have also undergone marked changes. The cells of the annulus, which at first were distinguished from the other cells simply by their form, begin to project above the level of the others and their division walls become thicker. At this stage (fig. 24) all the parietal cells are transparent and colorless, and are distinctly nucleated. The cells of the annulus on one side of the sporangium are rather more elongated transversely than the others, these being very much more strongly marked in four, or sometimes only three, near the base of the capsule, forming the *stomium*, or point at which the capsule opens. The division walls are also thicker in the cells of this structure which is specially well developed in the fern under consideration.

About the time that the spores are fully grown, but before the exospore is completed, the walls of the parietal cells begin to assume a brown tinge, this beginning with the cells of the annulus, whose division walls show it first. The color is at first pale yellowish, but the walls darken rapidly, until when mature they are a dark, almost perfectly opaque brown. The contents of the parietal cells disappear, leaving them dry and brittle, and when ripe, by the contraction of the cells of the annulus, the capsule is burst, the opening taking place at the stomium and the spores are discharged.

Each sorus develops a small indusium (fig. 12, *in*), which is nearly semicircular and attached by its lower margin to the base of the receptacle, separating the sori. It never attains much size and early withers away, its place being taken by the revolute margin of the leaf, this being thin and membranaceous, consisting for nearly half its width of a single layer of cells, which finally become dry and scarious, completely covering the sori (figs. 10, 28).

There are five sori developed upon each pinna-lobe of the fertile frond. They are at first sessile (fig. 11), but soon are elevated upon a pedicel, from whose central cells a short fibro-vascular bundle is formed connected with the vein above which the sorus arises (fig. 12). When complete they are so large that they touch one another, so that the whole lower surface of the leaf appears to be covered with sporangia.

CONTENTS.

Introduction. Page 17.

Section I. The Prothallium. Page 18.
The spores. Germination. Continuity of the protoplasm. Chlorophyll granules. Cell division. The apical cell. Formation of the sexual organs.

Section II. The Sexual Organs. Page 20.
The antheridium. Cell-division of the antheridium. Antherozoids. Escape of the antherozoids. Movements of antherozoids. The archegonia. Origin of the archegonia. Cell-division. Neck-cells. Canal-cell. Absence of ventral canal-cell. Germ-cell. Fertilization. Dioecism of the prothallia. Methods of growing the prothallia.

Section III. The Embryo. Page 26.
First division of the embryo. Establishment of the apical cells. The first leaf. Stem. Foot. Root. Primary fibro-vascular bundles. Venation of the first leaf. Scales. Development of the tissues of the primary root. The second root. The development of the tissues of the stem. Later development of the young plant.

Section IV. The Leaf. Page 31.
Origin of the leaves. The apical cell of the leaf. Scales and hairs. Structure of the young leaf. Division of the apical cell, and relation of the derivative cells to the tissues of the leaf. Differentiation of the tissues of the petiole. Fibro-vascular bundles of the petiole. Development of the pinnae. Formation of the veins. Fibro-vascular bundles of the veins. Epidermis and stomata. Development of the hairs and scales. Arrangement of the leaves. Fertile fronds.

Section V. The Stem. Page 38.
The apical cell. Cell division in the apical cell, and establishment of the tissue systems. Cavities in the ground tissue. Epidermis. Development of the fibro-vascular bundles. The complete rhizome. Development of the stolons. Development of the tissues of the stolon. First aërial leaves of the stolon. Branching of the stolons.

Section VI. The Root. Page 43.
Arrangement of the roots. Apical cell. Cell division in the apical cell and establishment of the primary tissue systems. Root-cap. Development of the permanent tissues. The complete root. Secondary roots.

Section VII. The Sporangium. Page 46.
The fertile frond. Young sorus. Succession of cell division in the mother cell of the sporangium. Archesporium. Division of the archesporium. Tapetum. Annulus. Formation of the spore mother-cells. Behavior of the nucleus of the mother-cell. Development of the spores. Ripening and dispersion of the spores. Arrangement of the sori.

EXPLANATION OF PLATES.

PLATE 4.

Fig. 1. A spore of *Onoclea struthiopteris* from which the exospore has been removed, × 150.

" 2. A similar spore beginning to germinate by the splitting of the middle coat and the protrusion of the endospore.

" 3. Spore in which the first root-hair, *r*, is separated from the body of the spore; the exospore is present, × 150.

Figs. 4–6. Later stages in which the body of the spore has divided to form the body of the young prothallium. In 5, the second root hair, *r'*, is forming, × 150.

" 7–11. Successive steps in the formation and division of the apical cell, *a*, of the prothallium, × 150.

Fig. 12. Showing the way in which the apical cell, *a*, is obliterated, × 150.

" 13. Young female prothallium, one month from the time of germination, × 150.

" 14. Young male prothallium with antheridia, "*an*," × 125.

" 15. Small male prothallium, consisting of but one row of cells. *an*, antheridium, × 150.

Figs. 16–18. Formation of the division walls in the antheridium, × 500. For the sake of clearness the contents of the cells are omitted.

" 19–22. Formation of the mother-cells of the antherozoids. In optical longitudinal section, × 500.

Fig. 23. First divisions of the central cell of the antheridium seen from above, × 500.

" 24. Ripe antheridium, × 500.

Figs. 25, 26. Successive stages in the formation of the antherozoids, × 625.

Fig. 27. Antherozoids escaped from the antheridium, but still enclosed in a thin membrane, × 625.

" 28. Complete antherozoids. *v*, vesicle containing granules, × 625.

" 29. Antheridium provided with a pedicel, *P*, × 150.

Figs. 30, 31. Early stages in the development of the archegonium, × 500.

PLATE 5.

Figs. 1–5. Early stages in the development of the archegonium, × 500. *m*, mother-cell of the archegonium; *b*, basal cell; *c*, central cell; *ne*, neck cell; *ca*, canal cell of the neck. Figure 1 is viewed from above, the others from the side.

" 6–7. Later stages in the development of the archegonium, × 500. *o*, the germ-cell; *m*, mass of protoplasm and mucilage formed from the canal cell. In figure 6 the contents of canal-cell have collected in three masses; Fig. 7, Ripe archegonium, opening and discharging the contents of the neck.

Fig. 8. Central cell and germ-cell of a ripe archegonium. *r*, receptive spot; *o*, germ-cell, × 500.

" 9. Antherozoids entering an archegonium, × 500.

" 10. Germ-cell, twenty-four hours after fertilization, × 500.

Figs. 11–16. Successive stages in the development of the embryo, in optical longitudinal section. Fig. 15, two-celled embryo; the nucleus of one-half has divided again; Fig. 11, four-celled embryo; Figs. 12–14, more advanced stages. All magnified five hundred diameters; Fig. 15, × 150. In all cases the section was perpendicular to the surface of the prothallium. *l*, leaf; *r*, root; *st*, stem; *f*, foot. The heavy lines mark the primary division walls of the embryo.

" 17–20. Young embryos, seen in optical longitudinal section, the section being parallel to the surface of the prothallium. Fig. 17, four-celled; Fig. 18, eight-celled; Figs. 19, 20, older embryos. All magnified five hundred diameters.

PLATE 6.

Fig. 1. Embryo seen in optical longitudinal section, the section parallel to the surface of the prothallium, × 500. *l*, leaf; *r*, root.

" 2. An embryo ready to break through the prothallium, × 150. Longitudinal section perpendicular to surface of prothallium. *l*, leaf; *r*, root; *st*, stem; *f*, foot; *pr*, prothallium; *ar*, neck of the archegonium.

" 3. A similar section through the leaf of a somewhat older embryo than 1, showing the bifurcation of the apical cell. *a a'*, the two new apical cells.

" 4. Root of the same embryo, × 245. *a*, apical cell.

" 5. Young plant with the first leaf and root complete, × 3. *pr*, prothallium.

" 6. Young fourth frond, showing the division of the apical cell, × 245.

Fig. 7. End of a young leaf, seen in optical longitudinal section, × 245. *a*, apical cell; *ep*, young epidermis; *me*, mesophyll; *fi*, fibro-vascular bundle of the rachis.

" 8. Transverse section of the complete bundle of the secondary rachis, × 125. *sh*, bundle-sheath.

" 9. Transverse section of the end of the bundle of the base of the petiole, × 125.

Figs. 10–14. Successive stages in the development of the stomata, seen from above, × 500. *x*, preliminary cell; *y*, mother-cell of the stoma.

Fig. 15. Apex of the stem of a mature plant, seen from above, × 150. *a*, apical cell; the six youngest segments are numbered, beginning with the youngest.

PLATE 7.

Fig. 1. Longitudinal section through the apex of the stem of a mature plant, × 150. *a*, apical cell; *x*, dermatogen; *y*, periblem; *z*, plerome; *m*, medullary parenchyma.

" 2. Longitudinal section through the apex of a young plant with three fully developed leaves, × 245. Letters as in 1.

" 3. Surface view of the apex of a stem of about the same age, × 245.

" 4. Part of a sieve-tube from the stem bundle, × 500.

" 5. A vertical section through the wall of a sieve-tube, × 500.

" 6. Vertical section through the apex of a strong root of a mature plant, × 245. *a*, apical cell; *c*, root-cap; *x*, dermatogen; *y*, periblem; *z*, plerome.

" 7. End view of the region of the apical cell of a medium sized root, × 245. The eight youngest segments are numbered.

" 8. Transverse section of the younger part of a root, × 125. The original sextant walls are indicated by heavier lines.

" 9. Transverse action of the complete fibrovascular bundle of the root, × 125.

" 10. Cross-section of the pinna of a fertile frond, showing the revolute edges and the position of the sori, × 30.

" 11. Vertical section through a very young sorus, × 150.

" 12. " " " " somewhat older one showing the indusium (*in*), × 60.

" 13. Mother cell of a sporangium (*in*), × 250.

Figs. 14–23. Successive stages in the development of the sporangium, × 250. All in optical longitudinal section except 19, which is seen from above. In all cases but 19 and 22 the plane of the annulus (*an*) coincides with that of the paper.

Fig. 24. Young sporangium about the time of the absorption of the tapetum, × 200. Optical section. The remains of the tapetal cells can be seen, and the mass of spore-mother-cells, *sp*.

" 25. Earlier stage in the division of the spores, × 375.

" 26. A full-grown sporangium, × 125. *an*, annulus; *st*, stomium.

" 27. Ripe spores, × 250; *a* from above; *b*, from the side.

" 28. Two lobes from the pinna of a dead fertile frond, showing the position of the sori, × 10.

III. The Introduction and Spread of Pieris rapae in North America, 1860–1886. With a Map (Plate 8).

By Samuel H. Scudder.

(Read May 4, 1887.)

It is well known that the different races of men have not always occupied the regions which they now inhabit, but that from the earliest times one wave of migration has followed another, in a manner that has proved very perplexing to the ethnologist attempting to follow them. That the lower animals also have had their migrations has been frequently proved by the occurrence of their remains in regions where they are not now found. Secular change of climate has been the great moving cause of most of the migrations of which we have any knowledge, with the single exception of the influence of man, and particularly of civilized man; he is everywhere upsetting the arrangements of nature, directly or indirectly exterminating all forms which cannot endure his presence or withstand the baleful influences which follow in his train. To minister to his wants, for instance, he brings into a new region a plant foreign to its soil that he may have the fruit ready to his hand. Without the natural hindrances which prevent its supremacy in its native home, it thrives so vigorously, if otherwise adapted to the place, as to supplant the natural denizens of the soil; these are supporting numerous animals, which in their turn suffer.

So it has doubtless been in all ages of the world, where by any of the multifarious means which nature employs she has herself upset the balance she had established, by bringing into a flora or a fauna some new element from without. Indeed, the history of animal and plant life has been a story of colonization. Any one who has observed the rapidity with which weeds spread over new countries, has read of the rabbit nuisance in Australia or seen the sparrow nuisance in America, will comprehend what a force colonization may have been. It was closely linked no doubt with the introduction of new types in past ages of the world.

The measurement of the spread of a newly introduced species has rarely been attempted. Indeed, in the nature of things it could scarcely ever be made except under circumstances which may fairly be deemed artificial, *i. e.*, in countries tolerably well settled with people intelligent enough to report accurately. Rarely, too, is the date of

introduction known. Yet as this could be approximately determined for the European cabbage butterfly recently imported into this country, and as by its ravages of a common garden crop it would make itself known by the damage it did and so force itself upon observation, it seemed a favorable opportunity to consider this question, which should not be missed; it was believed indeed that the correct measure of its spread might have some import for future investigation, and perhaps its lesson for him who would designedly introduce a new creature without regard to its relations to other animals.

As the insect has already crossed half the continent, the time has certainly arrived to make the necessary inquiries. Every one now knows that it has come to stay and little attention is given to its movements. Most of those who observed it on its first advent can still answer questions regarding its appearance by the aid of notes taken at the time, which later might not be possible. Accordingly, last autumn, I issued a circular to over six hundred persons in different parts of the country with the inquiry: "In what year, to your personal knowledge, did Pieris rapae first appear in your vicinity?" and asking also for any published data upon the matter. To this inquiry more than two hundred replies were received and from them, from the notes I had previously made based on special written inquiries in 1869 and 1870, and from various publications, the following account is drawn up.

The butterfly was first noticed in Canada and the actual history of our knowledge of its first appearance there is as follows:— Mr. Wm. Couper, a taxidermist and general collector, addicted especially to Lepidoptera and a good observer, living in Que-
1860. bec, first captured a few specimens in 1860 in the immediate vicinity of that city; he then looked upon the insect as a great rarity, and indigenous to Canada. In 1863 a new collector appeared in Quebec, Mr. G. J. Bowles, who, capturing it and finding no such insect described in American works, applied to Mr. Couper, only to discover him equally at a loss. Mr. Bowles then wrote to Mr. Wm. Saunders of London, Ontario, and to myself, and we both assured him that it was the European insect. Mr. Bowles' letter to me bore date Dec. 23, 1863.[1] In April and July 1864, these gentlemen read papers before local societies, both of which were published in whole or in part;[2] from these
1863. we learn that in 1863 the butterfly was very common and destructive in the neighborhood of Quebec and at Laval fifteen miles north, and had extended thirty miles to the northwest along the north shore of the St. Lawrence, though they had not been noticed beyond Point Levis on the south, nor taken at St. Anne's on the south shore of the St. Lawrence, seventy miles down the river, "where a collector of Lepidoptera resided." From what we know of the rapidity with which a single pair may propagate without hindrance from parasites, we may conclude almost with certainty that it was introduced in the early part of 1860, or at the earliest, at the very close of 1859. Owing, apparently, to Mr. Bowles' paper published in the Canadian Naturalist in 1864, in which he fixes the period of its introduction to Quebec "at about seven or eight years ago," it has been generally spoken of as introduced "in 1856 or 1857." But Mr. Bowles has allowed more time than is necessary, and records do not go back of 1860.

[1] Specimens were also sent to W. H. Edwards in Dec. 1862, but seem not to have been noticed by him.

[2] For Mr. Bowles' paper see Bibliography. Mr. Couper's appears to have been published only by extract in 1867 by Mr. Ritchie, *Can. Nat.* n. s. 3: 29.

Following the report of Mr. Couper of its distribution in 1863, we have at first but scanty information concerning its spread in Canada. Capt. Gamble Geddes of Toronto states that he first took it "about 1864, about ninety miles below Quebec; when I brought it back and showed it to Professor Fowler, then connected with the Natural history society of Montreal, he assured me it was quite the first that had been taken." This fixes the date of capture as before the publication (in Montreal) of Mr. Bowles' paper and indicates that in 1864, the insect had spread to Murray Bay, ninety miles below Quebec on the north shore of the St. Lawrence. 1864.

In 1866 begins our first considerable knowledge of the spread of the butterfly, as it has reached more populous districts. Mr. Wm. Saunders, on an excursion to the Saguenay (Can. Ent. 1, 11), found it at Cacouna opposite and a little above the mouth of the river and at Ha Ha Bay at the head of steamboat navigation on the Saguenay, as well as all the way to Chicoutimi, twelve miles further up the river; it was not, however, found at Tadousac at the mouth of the Sagnenay. We know by its subsequent record that it must have spread westward and especially southward by 1866, and it was indeed taken at Brome township within a dozen miles of the Vermont border by the Rev. T. W. Fyles. Dr. G. Dimmock, writing later in the N. E. Homestead (Vol. III, No. 46, Mar. 25, 1871), speaks of it as found this year also in northern New Hampshire and Vermont, but without specification, and Dr. J. C. Merrill reports the capture of a single specimen in the White Mountains (Proc. Bost. Soc. Nat. Hist., 11, 300); that it must have invaded these two states this year is certain from the considerable numbers found the year following. I have accordingly drawn the curve of its distribution to include this northern area. Moreover it is certain that it had reached this latitude in Maine, for there is a specimen in the Yale College Museum, No. 1,745, which was taken by Prof. S. I. Smith in Norway, Maine, in 1865, the earliest record of its capture in the United States. Probably it had covered the larger part of Maine wherever in the wilderness it could find a patch under cultivation for, writing from Garland in Penobscot Co., under date of Aug. 23, 1869, to the N. E. Farmer (N. S. III, 506), Mr. H. C. Preble says that he has "not been able to raise a respectable cabbage for some four or five years, on account of the ravages of this species of voracious rascals." Even if we credit him with some exaggeration from discouragement, we can hardly think the insect arrived there later than 1866, the more probably as Professor Smith again helps us by preserving in the Yale Museum two specimens captured by him at Eastport, on July 4, 1866. 1866.

The following year, 1867, marks a better known advance, for in May it reached Montreal, according to Mr. Ritchie (Can. Nat. III, 295) to the southwest, and extended on the southeast even to Halifax, Nova Scotia, as Mr. J. M. Jones testifies in a paper (Proc. N. S. Inst. III, 20) read three years later, a publication which has been entirely overlooked, its introduction to this point being heretofore placed as in 1871, since Mr. Jones later spoke of it as very abundant in the spring of that year (Can. Ent. III, 37). In Maine it was observed at Lewiston far toward the southern extremity of the state, though resident entomologists elsewhere in the state did not discover it until the following year. The late Mr. P. S. Sprague of Boston was one of those who found it at Lewiston (Proc. Bost. Soc. Nat. Hist., XI, 300) and Mr. W. Dickinson of Worcester, the other; the latter found it both this year and the next, but only in 1868 very destructive. 1867.

Notwithstanding the number of entomologists who annually visit the White Mountains, and the recorded capture by Mr. Merrill in 1866, *supra*, no one seems to have taken the insect in New Hampshire in 1867; though with its spread to Lewiston on one side and its appearance in considerable numbers in Vermont on the other, there can be little doubt that it was present, at least in the region north of the White Mountains and especially in the valley of the upper Connecticut. In Vermont, Dr. Merrill is our only authority (Proc. Bost. Soc. Nat. Hist. XI, 300). In August of this year he found the butterflies at Waterbury, Burlington and Stowe; in the first locality, on Aug. 29, they were "very abundant." During this year, therefore, the insect had fairly established itself in northern Vermont and New Hampshire, reached Montreal in its course up the St. Lawrence and pushed its advance guard to the Atlantic Ocean at Halifax and nearly to the Gulf of Maine at Portland.

In 1868, curious to say, our records are more meagre but in one respect very interesting. It was only in this year and toward the end of it that it reached Waterville, Me., to judge from the fact that it was first seen in the early spring of 1869 by a very careful resident observer, the late Prof. C. E. Hamlin. The butterflies must have come from wintering chrysalids near by. In New Hampshire and Vermont its progress was steady but not extensive. In New Hampshire it was taken this year by Mr. M. C. Harriman at Warner near the Southern Kearsarge, and was seen, according to Dr. C. S. Minot (Am. Ent. II, 75), near Lake Winnepesaukee. In Vermont it had extended to about the same points, for it was common at Woodstock (F. R. Jewett) and not uncommon in August in Sudbury (S. H. Scudder), while in all the track behind it was abundant enough. Writing to me from St. Albans in 1869, Mr. N. C. Greene said that in the previous autumn his 3000 cabbages had from ten to fifty worms on a head; he had not previously noticed them at all and thought they first came in 1868, whereas they must have reached St. Albans early the year before that. In the valley of the St. Lawrence there is nothing, for a time, to gauge its movements, but writing in Sept., 1869, Mr. A. S. Ritchie says that he has heard of its ravages as far west as Chateaugnay, so that it doubtless was to be found there in 1868. Nor can we say more concerning its extension into the eastern provinces, though I am told by Mr. G. F. Matthew that it appeared at St. John "within two or three years of its recorded advent at Quebec" and, therefore, certainly not later than 1868. Indeed we have seen that it was just on the border, at Eastport, in 1866, and Prof. L. W. Bailey, writing in 1886, says it has been at Fredericton "for at least twenty-five years," but he speaks only from recollection.

1868.

But the chief interest of the year 1868 lies in the fact that it was then independently introduced into the country at New York. Rumor has it that a German entomologist in Hoboken received some living pupae from Europe to raise for his cabinet, that they emerged from the chrysalis in his absence and afterward escaped from an opened window. But however this may be, we know from several sources that it was to be found about Hoboken and Hudson City, N. J., this year. Mr. John Hampson, a collector of twenty-six years' experience, living in Newark, took a single specimen there this year in May (J. B. Angelman). The late Mr. W. V. Andrews, sending me caterpillars in July, 1869, said it had "been known for a year or two," and the same writer says (Can. Ent. II, 55) in Jan., 1870, "the increase of this insect *during the last two years* is marvellous."

Indeed its abundance the next year at Bergen Hill, West Hoboken and Hudson City is proof that the first specimens came to the spot in 1868. The fact that New York City does not draw upon the Lake Champlain region for its cabbages (as I am informed by Mr. Lintner of Albany) and the subsequent evident spread of Pieris rapae from two points prove this to have been in all probability an independent introduction into the country. It is only surprising that it was so long delayed.

The spread of the butterfly from this new centre during 1869 does not appear to have been very great. That in scanty numbers it followed the track of the railway toward Philadelphia is probable from the nature of things and from the fact that Mr. J. P. R. Carney took a specimen that year within the present limits of Camden, which he at the time supposed came across the ocean in a vessel, then unloading near by; yet Mr. Andrews wrote, under date of Aug. 26th in that year, that while "quite abundant in the neighborhood of Bergen Hill and Hudson City, ten miles hence I could not find a single specimen." It reached West Farms in the autumn of that year, where it was seen by Mr. James Angus, but not taken; specimens were however taken the following April fresh from the pupa. It was also reported as very common in 1869, in the parks and gardens of New York city, by several observers, though Mr. T. L. Mead, an enthusiastic lepidopterist at the time and a resident of the city, records the capture of a single specimen on the Jersey side of the Hudson River (Can. Ent. II, 36) as if its presence in the metropolis were quite unknown to him. It seems probable therefore that its occurrence in the vicinity of New York was taken by outsiders for its presence in the city itself. Still it may well have been present in spots not visited by Mr. Mead, and I myself found it swarming about parks in the heart of the city in June, 1870. I can find no record of its appearance this year in Long Island. In 1869, then, with the exception of a straggler toward Philadelphia, the butterfly is not known to have spread more than ten or fifteen miles in any direction from New York. 1869.

The northern horde of invaders in the meantime was steadily pushing southward; how far to the west is quite unknown, for there are no reports for 1869 from the St. Lawrence valley, except the one above referred to, of its ravages at Chateauguay. So too from Vermont and New Hampshire, the only accounts are of its great abundance in the northern portions and its appearance in every quarter there, including the alpine regions of the White Mountains. In Maine, moreover, it had everywhere reached the seacoast and was found in numbers in all the inhabited portions. It was abundant at Bangor (Chase, Riley) and reported from Norway (Smith), Mt. Desert Island, end of July (B. P. Mann), Eastport (Smith), and Portland (Dimmock). It was indeed along the seacoast that it pushed its way southward most rapidly, for in the spring of this year it reached Boston. I saw my first specimen on July 17, on Boston Common, but other observers were ahead of me. Mr. P. S. Sprague, for instance, saw it in the same spot April 26, and Mr. F. A. Clapp on May 20; by the autumn they were not very uncommon. A single specimen was also said to have been seen this year near Worcester, according to a paper read by Mr. W. Dickinson before the Natural history association of that city (Worcester Spy, March 16, 1870), but this is rendered exceedingly doubtful by subsequent reports. Probably the nearest point at which the northern horde approached the southern was somewhere on the Hudson or Connecticut rivers not far above the latitude of 43° N.

For although, as we have seen, it was abundant at Sudbury in August, 1868, it was not until the spring of 1870, to which year we now turn with some curiosity, that it was recognized in the centre of Eastern New York, where two such entomologists lived as Dr. Asa Fitch and Mr. J. A. Lintner. East Greenwich, where Dr. Fitch resided, is almost halfway from Albany, Mr. Lintner's home, to Sudbury, Vt., yet in both these New York localities it appeared for the first recognized time in 1870, and then not until midsummer. Under date of March 16, 1872, Mr. J. A. Lintner writes me in detail regarding its appearance this year: "I observed it here [Albany] for the first time on July 24. Dr. Fitch reports it at his residence in East Greenwich, Washington Co., thirty-two miles in a direct line E. of N. from Albany, on the 2d of August. On August 6, I saw it quite numerous at Saratoga Springs, thirty miles north, and on the 8th at Glen, Warren Co., sixty-five miles W. of N. of Albany. During the month of July a large number of the butterflies were seen at Crown Point and Westport on Lake Champlain, and at the latter place [a short distance northwest of Sudbury, Vt.] the garden cabbages were so utterly ruined by the larvae that they were pulled up and fed to cattle . . . Sept. 11, I observed it abundantly at Utica, Oneida Co., ninety-five miles west by rail. Oct. 8, I saw larvae but no butterflies at Cherry Valley, Otsego Co., fifty miles westerly. The latter part of July it was seen at Sharon Springs, forty-five miles west; while at Schoharie, an intermediate point thirty miles west, I did not detect it until perhaps two weeks later." As it is not reported from the eastern end of Lake Ontario for a year or two, the butterfly probably reached Utica by the eastern rather than the western side of the Adirondack region and thus have spread more rapidly in a western than in a southern direction from the southern end of Lake Champlain. Moreover, Mr. H. B. Hawkins tells me, on the authority of Mr. W. E. Yager, editor of the Oneonta Herald, that it appeared this same year in Oneonta, Otsego Co., considerably to the south and east of Utica. Along the Hudson, Mr. Lintner does not report it as extending farther south than Bath (Ent. Contr. II, 54) five miles below Albany in September. There can be no doubt that it had this year completely overrun Vermont and New Hampshire, though the only records I have in the southern portions are that the first specimens were taken by Mr. C. P. Whitney at Milford, N. H., on May 26 of this year, that it was abundant there by autumn, and taken in numbers at Walpole, N. H., in June (S. I. Smith). But it had followed down the Connecticut valley much farther than this, for it was taken at Holyoke, Mass., by Mr. J. E. Chase; and Dr. George Dimmock reports (N. E. Homestead III, No. 46, Mar. 25, 1871) that the first specimen was taken near Springfield in the early part of May on the Longmeadow road; that it was abundant before autumn and that in July he took it in considerable numbers as far south as New Britain, Conn. The first noticed by Mr. E. Norton at Farmington, Conn., were also seen this year but "not often"; in the following year it was quite common. It also became common this year at Walpole, Mass., seventeen miles southwest of Boston (Miss C. Guild). It would appear therefore that, at the close of 1870, the southern limits of the northern host were at about the parallel of 42°, 10′–30′ with a considerable extension down the Connecticut valley.

1870.

Meanwhile the southern horde was extending its outposts. The entire extent of Long Island was occupied this year, for Prof. S. I. Smith found the butterfly very common at Fire Island Beach in August and Mr. B. H. Foster reports destruction at Babylon (Am.

Ent. II, 341). In further direction toward the northern band, Mr. Dimmock found "a few" at Bridgeport, Conn., in July, which may have belonged to the other group, but far more probably were the descendants of those that occupied West Farms the year before. Dr. S. Lockwood tells me that it invaded Monmouth Co., N. Jersey, in 1870 and in October of this same year the editor of the American Entomologist saw it around fruit stands in Philadelphia (Am. Ent. II, 338); Mr. W. D. Doan writes me that it appeared in scanty numbers this year at Atglen, Chester Co., Penn., and Mr. Townend Glover in one of his Government Reports says that it appeared even as far as Baltimore "anterior to 1870"; but this I think must be an error of memory. It appears then that the southern horde did not this year quite reach the northern, but the two approached each other so nearly as inevitably to mingle in 1871; that the northern had almost everywhere reached the eastern seashore of New England and the Canadian provinces, and on the west had extended probably to Lake Ontario and nearly to central New York. The southern, on the other hand, had covered Long Island eastwardly, and was pushing its way also along the northern shore of the Sound, while its main army was directed southward, had covered New Jersey, and extended into eastern Pennsylvania.

In the next year, 1871, these two armies, having devastated the country with independent forces for fully three years, met and mingled, and then swept westward and southward with increasing rapidity. They covered all the ground which lay between the outposts of the previous year, this being the year in which it was first seen in Rhode Island, at Providence (H. L. Clark), and at Hunter, N. Y. (W. H. Edwards). It also extended to some of the higher regions previously untouched but swept past, such as Williamstown, Mass. ("in force" S. Tenney), and became as usual excessively common where it had only appeared scantily the year before. There were even some spots not invaded until 1872, and it would appear that the advance guard, which swept down the rivers flowing southerly and along the seacoast, left the inland districts long untouched. Thus it is reported as not seen in Stowe, Mass., at the close of 1871 (C. A. Emery). Mr. Dickinson showed to the Natural history association of Worcester in 1872 several specimens that had been found in a garden there, as if they were of special interest as new comers (so that the rumor that one was taken there in 1869, *supra*, must be an error), and it is thought not to have appeared in Sherborn until 1872 (A. L. Babcock). By that time it had probably overrun every nook and corner of New England. Similar irregularities appear in all its subsequent movements westward. 1871.

Of its westward movement in 1871, we still have no information from northern New York or north of the boundary, and can only judge by subsequent notices that it must have reached at least the extreme eastern end of Lake Ontario. It had certainly passed the centre of New York, being found common at Ithaca this year (J. H. Comstock, L. O. Howard), where indeed it made its first appearance the preceding year according to Mr. Howard, though Mr. A. C. Weeks thinks it did not occur in Tompkins Co. in 1870. It was "troublesome" this year or 1872 at Cazenovia (L. M. Underwood), while Mr. Saunders states in his address to the Entomological society of Ontario (Rep. 1877, 5) that "by 1871 it had travelled . . . west to the middle of the state of New York". In Pennsylvania it is reported as harmful this year in Luzerne Co. (T. Glover), and as present at Easton (Mrs. J. P. Ballard) and Lancaster (S. S. Rathvon); this does not greatly increase its westward range. But it had pushed somewhat farther southward,

following the coast line; injury was done to crops in Cecil Co., Md., during this year, according to the reports of the Agricultural Department (Glover), and it appeared in Baltimore according to C. R. Dodge (Rural Carol., August, 1872). Writing me from Spottsville, Va., Mr. B. W. Jones says, "It was a general complaint (in Surry Co.) as early as 1870–71 among farmers, that they could raise no good cabbage on account of it. In 1872–73 it infested the gardens about Petersburg in untold numbers." Yet it was not seen in Washington until 1872. This year then is remarkable for the union of the two armies and the considerable westward extension in New York.

In 1872 we again are able to trace the forward movement of the butterfly in Canada, where it originated, and from which information entirely fails from 1867, when it reached

1872. Montreal, until this time. For now we learn that it had passed by this time along the northern shore of the St. Lawrence and Lake Ontario to Belleville and Trenton, Ontario (Bethune, Can. Ent. v, 41). But south of the river and the lake it had pushed much farther, viz., through the entire length of the state of New York, so as to invade Canada from the United States! It did not reach Port Hope, Ontario, from the east, where Mr. Bethune was awaiting it ("we fully expect to see it at Port Hope this year,"—Can. Ent. v, 41,) until July 1873, but it appeared at Ridgeway, Welland Co., "not in great numbers" in 1872 (A. H. Kilman), and at Toronto in August, 1872 (W. Brodie—*cf.* Canada Farm., 1875, 127). This makes it highly probable that it reached Buffalo this year, of which I could not otherwise speak, as the testimony of my correspondents is widely conflicting. Certainly it reached Brockport, for it was taken there in September by Mr. David Bruce, and the next year had certainly spread much farther west on the southern than on the northern shores of Lake Erie. It was in this year that it reached Delhi (L. O. Howard). In Pennsylvania, though it probably reached Centre Co. in this year (W. A. Buckhart), it was possibly checked in its westward spread by the Alleghanies, as we do not hear of it in the western part of the state. It reached Washington early in this year (Monthly Rep. Dept. Agric., June 1872, 218) but how much farther south it passed we do not know. As however we have already heard of it in Virginia it is probable that it had extended southward at something like its previous rate and we have accordingly drawn our curve, to correspond with this.

In 1873, as before stated, it reached Port Hope, and "F. C. L." reports taking his first specimen at Dunn in Haldimand Co., Ont. (Can. Ent. 6, 60), and some were taken at

1873. Hamilton (J. A. Moffat), where one would have looked for it the preceding year from its presence then at Toronto. This year it had entirely covered New York state, though there were places even in the eastern half, such as Norwich, where it did not appear until this year, at least in any number (J. S. Kingsley). It was found sparingly at Cleveland in the spring of this year[1] (J. G. Gehring), but from here southward our information is practically a blank. We have, however, two curious items: it is reported by Mr. C. R. Dodge as being destroyed by parasites in Louisville, Ky., in this year, which implies that it appeared there at least the year before (probably Mr. Dodge's informant mistook the destructive southern cabbage butterfly for this).

The other is a very definite piece of information from Prof. L. R. Gibbes of Charleston,

[1]This is the first definite statement of its advent in Ohio, but Mr. W. H. Edwards, in Part 8 of his Butterflies of North America, says "it swarms [August, 1871] in many parts of New York and New Jersey and in Ohio." The last is clearly an error.

who, in a recent letter to me, after mentioning the year 1870 as one which was remarkable for the number of Lepidoptera seen in that city, says that *P. rapae* (of which he possessed English examples in his cabinet) was not to be found, but "in 1873 I observed it as not uncommon in this city, and recognized it at once, while flying, as distinct from its congeners *P. monuste* and *P. protodice* . . . I have seen it I think every year since." This appears to be an unquestionable independent introduction of the species from a coasting vessel, and it is due to this probably that we find it invading the southern Atlantic states sooner than we should otherwise anticipate. In the curves, therefore, I have given this new southern horde a distinct claim to local independence, and brought the northern curve to the ocean at a comparatively high latitude.

In 1874 we again hear of the insect to the east of its point of origin, N. Corneau reporting it as rare at Godbout river on the lower St. Lawrence, the northeasternmost point from which it has yet been recorded (Can. Ent. VII, 208); its progress westward in Canada seems to have been very slow. It was abundant now at Hamilton but it did not reach Paris this year or certainly not until the very end of the year. It had become noticeable at Cleveland by its ravages during this summer[1] as well as in western Pennsylvania (T. B. Comstock, Am. Nat. IX, 426). It made its appearance among the mountain valleys of West Virginia in September, where it became abundant the following spring (W. H. Edwards, Pap. I, 96). It was "by no means rare" in Virginia (Bethune, *loc. mult.*) **1874.**

Of the extension of the southern horde we know nothing, but from the record of later dates I have assumed an enlarged curve which seems best to agree with the facts.

But here enters a new factor. Dr. A. W. Chapman, a well-known and experienced lepidopterist, in response to my circular, writes to me from Apalachicola, Florida, that the butterfly first appeared there in 1873 or 1874; adding that it has not yet become common, only half a dozen being seen in a season. Here we have a second southern coastal introduction, unless indeed it was imported from Charleston by rail direct, as seems more probable. Its appearance, however it came about, at these two southern stations at such an early period explains why, when the insect does not flourish so well in the extreme south as farther north,[2] it managed to reach Alabama at least as soon as it obtained a foothold beyond the Mississippi.

Turning now to the year 1875 and beginning as before at the north, we find that according to Mr. Saunders it reached Paris, Ont., in the spring of 1875, and London in August (Report Ent. Soc. Ont. 1875, 31; Can. Ent. VII, 163). The same good authority tells us (*ibid.*) that it had reached western Ohio, and a gardener in southwestern Ohio reports that it first troubled him in 1876 at Mt. Repose, Clermont Co., and therefore presumably reached that place by 1875 (F. G. Fisher). It did not however reach Cincinnati until the following year (C. Dury) though it had followed the western Alleghanies down to Maryville, Blount Co., eastern Tennessee, a little south of Knoxville, where Mr. E. M. Aaron saw it in 1875. It was now common in West Virginia, and presumably extended into North Carolina, though we have no report from **1875.**

[1] Dr. J. F. Isom reported that it first appeared at Cleveland in the spring of 1875 (Can. Ent. VII, 180); but he is certainly in error.

[2] In evidence of this, the fact that it is still scarce at Apalachicola is supported by its failure to invade the peninsula of Florida.

there until 1878, when Mr. W. V. Andrews found it in March at Asheville. The southern part of our line for this year is, therefore, purely conjectural, as are also the lines for the southern colonies, from which we have no data.

There enters now a good deal of confusion in the dates of its appearance as obtained by correspondence in different parts of the west. The insect had become abundant on all the main railway lines running east and west and was liable to be forcibly carried in any direction. Wherever a pair, male and female, happened after all vicissitudes to come together, there would be the point for the introduction of a new colony; for mignonette or cabbage or turnip would be found somewhere about; and the only wonder is that the movement of the throng was as regular as it was.

During 1876 it covered the whole of western Ontario (Saunders *loc. cit.*) and extended into eastern Michigan (A. J. Cook); Mr. E. A. Strong even states that he took it at Grand Rapids in 1875, but this I think must be a fault of recollection. Below the Lakes however, it moved on more rapidly. It is possible, if not probable, that one of the roadside colonies to which I alluded above was established in central Indiana before this, for Mr. S. G. Evans says that *Pieris rapae* was common in Evansville when he commenced collecting there in 1874; and Dr. G. M. Levette writes me from Indianapolis, "From recollections of myself and others I would place it [the introduction of *P. rapae* at that point] in 1872 or 1873." We have the very definite statement from Dr. F. W. Goding that he captured a female in his father's garden in Kane Co., Ill., 44 miles west of Chicago on Sept. 17, 1875. A few days afterward he saw several, as he now distinctly remembers, in cabbage fields west of Chicago, flying in company with *P. protodice*. Mr. J. W. Huett also writes that he first saw the butterfly at Farm Ridge, LaSalle Co., in the spring of 1874 or 1875, in scanty numbers. It would therefore appear highly probable that, a year or two in advance of the normal rate of progress, *Pieris rapae* swept into Chicago on a railway train. We have no further record for this year of the advance of the great horde, but simply from analogy and subsequent facts, the curve of its probable progress has been placed on the map.

1876.

In 1876, however, we have indications of the spread of both of the southern colonies, for in October of this year, Dr. A. Oemler detected the butterfly at Wilmington Island off Savannah,—evidently an extension of the Charleston colony of 1873; while the fact that the butterfly was as common in 1876 as now at Lumpkin in the southwestern part of the state, as I am informed by Mr. A. W. Latimer, indicates the spread of the Apalachicola colony.

In 1877, to begin now with the south, these two southern colonies probably merged, for the butterfly was common at Macon, as reported by Prof. J. E. Willet at the August meeting of the Georgia Horticultural Society, a point which probably might have been reached by either colony this year, though not by the northern horde for a year or two later, to judge by all accounts. For, to forestall the succeeding years a little, the pest was not noticed in northern Alabama until 1879, nor at Atlanta, Georgia, until 1880, nor at Chester, S. C., until 1881 (L. M. Loomis).

1877.

From these points to Illinois is a long leap, but for this year it has no record. Excepting for the notice of its common occurrence at the head of Lake Rosseau in the Muskoka District, east of Georgian Bay, Canada (Saunders, Can. Ent. IX, 185), the only

remaining data are for Illinois and Michigan; the butterfly had covered the lower half of the lower peninsula of Michigan (A. J. Cook, E. W. Allis) and part of Illinois. The specific points which it had reached in the latter state are the region about Chicago, — Maplewood (C. Thomas, G. H. French), DeKalb Co., sixty miles west of Chicago (F. M. Webster),— Decatur (W. Barnes), and Champaign, in the autumn (C. Woodworth). The first two of these may easily have been the mere extension of the Chicago colony, the latter two of the Indiana, but, in all probability, the succeeding year saw a blending of all the colonies both north and south.

For then, 1878, not only is almost the whole of Illinois invaded, but the advance guard has pushed across the Mississippi and intrenched itself in Iowa and Missouri. According to Dr. C. Thomas, it appeared at Carbondale early in the year and "in injurious numbers" at Springfield (9th Rep. Inj. Ins. Ill., 9). It had crossed the Mississippi at at least two points. Prof. R. R. Rowley writes me from Curryville, Pike Co., Mo., that he collected two specimens on radish blossoms at Louisiana in that county in July, 1878, and Prof. S. M. Tracy says that he noticed it at Columbia, in 1877, the first year of his residence there[1]. Further, Mr. J. M. Myers writes me that five or six specimens were taken at Fort Madison, Iowa, in the autumn of 1878; and the same fact is reported by Mr. A. W. Hoffmeister (Trans. Iowa Hort. Society, 1879). There can therefore be little doubt that it was in this year that it first crossed the Mississippi. In Tennessee too, it was close to the Mississippi in 1878, for according to Mr. F. P. Hynds it appeared this year at Ralston Station in Weakley Co.; and it was in March recorded from Asheville, N. C., by Mr. W. V. Andrews (Can. Ent., x, 98). 1878

In 1879 it had extended up the peninsula of Michigan, having been taken at Ludington either this year or the preceding by Mr. N. B. Pierce, and had invaded Wisconsin, appearing in May about Racine (P. R. Hoy) and being abundant there (O. S. Westcott) although it did not reach Milwaukee that year (R. T. Church). Dr. Hoy's printed statement will be found in his list of Wisconsin Lepidoptera, and should be noticed by any one led astray by the statement in the American Entomologist (II, 79) that it was said by Dr. Hoy to be tolerably common in Wisconsin in 1869. This last publication may account for the statement by Dr. Fitch in his thirteenth Report on New York insects, in speaking of the new cabbage pests, that "the present year (1870), probably favored by the protracted drought, they have suddenly overspread a large portion of the middle and *western* states," when in fact they had not extended westward beyond the middle of his own state. Possibly it was based on the statement already referred to in Edwards' Butterflies. Mr. Riley has also stated (U. S. Agric. Rep., 1883, 109) that it had appeared in Green Bay (Wisconsin) in 1874, but that probably his correspondent mistook an allied species for it. In Iowa it made rapid advances. We have already seen it at Fort Madison in the southeastern corner. It probably appeared in 1878 also at Keota in Keokuk Co., for it was destructive there before the end of 1879 (A. S. Van Winkle). At Muscatine, according to Miss Alice Walton, now Mrs. Beatty, it appeared in the latter part of May (Proc. Muse. Acad., Nov. 3, 1879) and according to Mr. F. M. Witter (Proc. Iowa Acad., 1875–80, 21–22) became destructive that year. It appeared this year also in Linn Co., where it was very destructive (Riley). But it went beyond 1879.

[1] This is certainly possible, but it was more probably in 1878, to judge by other reports.

the eastern tier of counties, for it was found at Des Moines, according to a correspondent of the Prairie Farmer of Chicago (Am. Ent., III, 55), and in the autumn it reached Ames (H. Osborn), and had even advanced by midsummer to Omaha in Nebraska, according to Mr. L. Bruner, *i. e.*, across the entire state of Iowa. In all probability it may have been prematurely carried to that great railway centre by the freight trains. The surprising thing about this is that it appeared to have no outcome, as we shall see. The butterfly appeared also about St. Louis this year (Miss M. E. Murtfeldt) and at many localities in Alabama, such as Marion (J. F. Bailey, Am. Ent., III, 107) and Selma (Riley), though Mr. Riley did not see it at Mobile on a visit there (U. S. Agric. Rep., 1883, 109).

In 1880 it had advanced in the north, according to Mr. Saunders, to Manitoulin Island near the northeastern end of Lake Huron (Can. Ent., XII, 192–195), to the Sault
1880. Ste. Marie, to Rochester in the southeastern corner of Minnesota (C. N. Ainslee), to West Point, Nebraska (L. Bruner), to Lawrence, Kansas, in March (F. H. Snow) and to Manhattan in the same state (W. Knaus, E. A. Popenoe). Dr. W. S. Newlon writes me that, according to his note book, it appeared at Oswego in the southeastern corner of the state on June 10, 1879, but he is not quite positive about the year. It is also reported this year from Atlanta, Ga., in July, by C. V. Riley (Am. Ent., III, 200). It must have been there the year previous.

In 1881 we have few reports of its extension, but it was this year that it became common on Keeweenaw Point, at Calumet, Mich. (E. T. Custis), though the post-
1881. master at Kasson, Leelenaw Co., told Mr. E. W. Allis that it did not appear in that place until a year or two later. It was as late as Aug. 3 that Mr. G. M. Dodge first saw it at Glencoe, Dodge Co., Nebraska, not fifty miles from Omaha (Can. Ent., XIV, 39) and not until this year did it make its appearance at Salina, Kan., becoming common in 1882 (A. W. Jones). It is also reported as appearing in 1881 at Bastrop, Texas (L. Heilegerodt).[1]

In 1883 (there being no statistics obtainable for 1882) we have several very interesting extensions. Mr. Walter Hayden, returning to England in 1883 from Moose Fac-
1883. tory at the extreme southern end of Hudson Bay, took with him an interesting collection of insects, among which Mr. J. Jenner Weir found a single pair of *P. rapae*, which were all he had taken there in a residence of five and a half years. Presumably the insect had arrived shortly before his departure. It was only in this year, according to Mrs. E. A. Patten, that it appeared at Minneapolis, Minn., yet it was now that Capt. Gamble Geddes took it in Manitoba along the line of the Canadian Pacific Railway, at least as far as Brandon, about longitude 100°. Further, Mr. Charles S. Brown of Ludden, Dickey Co., Dakota, writes me that he reached that country in 1883 —one of the first settlers there — and noticed then a few specimens of the butterfly, which has since become common. It is evident that it has nearly outrun the tide of civilization.

But even this record is outstripped by the report that it actually reached the Rocky mountains in Montana in 1884. Two correspondents have answered my inquiries from

[1] Mr. N. Coleman found it in Marshall, Texas, when he moved there in 1884. He thought it had not been there long.

there; one has not seen it and says it must be rare or local if there at all; the has occasionally noticed a Pieris, but took it to be *P. oleracea* (R. S. Williams); the other, Mr. F. W. Anderson, says he saw none in 1883, one in 1884 and another in 1886. 1884.
North of the boundary, according to the report of a four years' resident, the insect has not yet reached Regina (N. H. Cowdry).

A few words only will suffice for all later statistics. In 1885 it is recorded from Duluth, at the western end of Lake Superior (W. H. Edwards); and Mr. David Bruce, who has spent the last three summers in Colorado and has closely watched all white butterflies on the search for some of the rarer forms, met with *P. rapae* for the first 1885-6.
time in 1886, seeing a dozen specimens about Denver between August and October. In this same year it apparently made its first advent into the eastern half of Florida. Enquiries, last autumn, of several entomologists residing there, Messrs. Ashmead at Jacksonville, Hubbard at Crescent City, Mead and Chase in Orange Co., elicited the uniform response that the butterfly had not reached there; but Dr. J. M. Wheaton of Columbus, Ohio, writes me that he obtained a single battered specimen about the first of April, 1886, while on a visit to Jacksonville. There is probably, therefore, no state in the Union, east of the Rocky Mountains, where it does not occur, though it has not been reported, to my knowledge, from Mississippi, Louisiana or Arkansas. It is hardly possible that it has not covered nearly or quite the whole of each, though Mr. R. d'Ailly of Malvern, Arkansas, writes me that it has not yet reached that place in the centre of the state.

If now we examine the map upon which these statements have been represented, we shall be struck, I think, by two or three principal points: 1. The more rapid spread of the butterfly, at first, toward the east and southeast until it reached the sea, rather than toward the southwest along the valley of the St. Lawrence. 2. The comparatively small amount of hindrance mountainous and elevated countries seem to have presented in the early part of its career; indeed, if the first record of its appearance in East Tennessee is correct (and we have excellent authority for it) these would seem in the warmer latitudes to have offered a distinct highway for the movements of the army, which the curves for 1874–1877 are meant to show. 3. The favorable influence of colonies on the spread of the pest with the single exception of that at Omaha. 4. The excessively rapid, forward movement toward the west and southwest as soon as the Valley of the Mississippi is reached; compare, for instance, the five years' advance from Cincinnati, Ohio, to Lawrence, Kansas, or to Bastrop, Texas, and the otherwise rapid five years from central New York to western Ohio, or the five years it took to cover the New England states. 5. The natural limit to its southern extension, as shown by the fact that it can hardly maintain itself at Apalachicola and has not pushed its way into the peninsula of Florida beyond, hardly to, Jacksonville, although it has for ten years been within what would elsewhere be not more than a year's flight away.

It may here be mentioned, as a fact noted by every one who has studied butterflies and by many others, that as fast and as far as *Pieris rapae* has spread, it has almost exterminated the native white butterflies, both the southern cabbage butterfly, *Pontia protodice*, which is itself harmful, and *Pieris oleracea*, which is comparatively innocuous. It is also observed that the second year after the advent of *P. rapae* is the one in which

it is most numerous and does the most damage. Its parasites then follow it up and its injuries, though still serious, are by no means so alarming.

I have purposely refrained from mentioning hitherto the fact that, in the opinion of some entomologists, *Pieris rapae* is indigenous to the Pacific coast of America, or at least has been known there for fully a quarter of a century and no one knows how much longer. Specimens were first brought east by Mr. A. Agassiz in 1859. It is well known that the butterflies (not to mention other animals) of the Pacific coast are more nearly allied to those of the Old World than are the butterflies east of the Rocky Mts.; and therefore, to one regarding these western Pierids as identical with *P. rapae*, they may well be looked upon as autochthonous, inasmuch as in the Old World *P. rapae* extends from the Atlantic to the Pacific, from Great Britain and Barbary to Kamtschatka and Japan. In his elaborate paper on the American forms of Pieris allied to *P. napi* of Europe (Papilio I, 83–99, pl. 2–3), Mr. W. H. Edwards has argued that all the American species of Pieris (as I have limited it) which do not belong to the European *P. rapae*, are to be classed with the European *P. napi*, and in his last catalogue he has so arranged them, excepting that for some unaccountable reason he separates as a distinct species *P. virginiensis*, which he himself stated three years earlier had given birth in Mr. Mead's breeding experiments to the form *oleracea*.

This is not the place for the discussion of affinities, so I can only here express my present dissent from the conclusions of Mr. Edwards, mainly upon the very grounds set forth in his paper, in which I think he has confounded two distinct species. My own belief is that we have in America, in addition to the introduced *P. rapae*, two distinct autochthonous species, each of which shows seasonal dimorphism similar to that of *P. rapae*, and at least one of them some marked geographical races. One species, generally known as *P. oleracea*, covers the continent from ocean to ocean and reaches from Alaska and Labrador to Central California, Colorado and Virginia. It has been described under many different names, such as casta, cruciferarum, marginalis, frigida, hulda, and virginiensis, besides several varietal designations. As a general rule it has no spots upon the upper surface, though these sometimes appear, probably by reversion. The other species, *P. venosa*, has been hardly less tormented with appellations, having been also christened pallida, yreka, castoria, nasturtii, resedae and iberidis. It is found along the Pacific coast from central California to British Columbia at least as far as Lat. 52° N. It is closely allied to and may be said to represent *P. napi* in this country. It is, however, as distinct from *P. napi* as *P. napi* is from *P. rapae*, and the only logical outcome from the position assumed by Mr. Edwards is, in my opinion, to consider all these species of Pieris,—rapae, napi, oleracea and venosa, as different forms of one species. It matters little whether they are looked at in this light or as distinct species, for they undoubtedly came from the same stock. The only claim I would make is that if *P. rapae* and *P. napi* are distinct species, as they are universally considered in Europe, then the American species, previous to the introduction of *P. rapae* into eastern Canada, were distinct from the European and from each other. That certain forms of each of them, and especially of *P. venosa*, might readily be taken (as has been done) for *P. rapae* is unquestionable, and it is possible that the species, seen in 1884 and again in 1886 at Great Falls and the Belt Mts., Montana, was *P. venosa*, so marked. I have accordingly cov-

ered the area upon the map over which *P. venosa* is known to extend with close cross ruling, and that which it may probably also occupy with more open ruling. It will thereby be seen that the introduced *P. rapae* is rapidly progressing toward its near of kin. It may well be believed that if *P. rapae* has in the last five years crossed the high plains of Kansas and Nebraska on its westward march, as it has done, the butterfly considered by Mr. W. H. Edwards and others as *Pieris rapae*, which has been on the Pacific coast since 1859, would, in more than a quarter of a century, if it were *P. rapae*, certainly have extended eastward across the less arid country along the northern boundary of the United States to a proportionably longer distance,—which it certainly has not done. It therefore fails in one characteristic of that ravenous and destructive species. It should be added that the only forms considered by any one as identical with *P. rapae* are those described by myself as *P. marginalis* and by Mr. Reakirt as *P. yreka*. They came from California, Oregon and Washington Territory.

With regard to the nature of the documentary evidence a few words may be said. One would expect that much might be learned from agricultural and horticultural journals about the movements of the butterfly, but a great amount of time has here been wasted in vain search; very little was to be found and that little generally so vaguely stated as to be valueless. Direct enquiry has been almost the sole resource of value after the entomological journals, and especially the pages of the Canadian Entomologist.

In the mass of information received from very various quarters in reply to my circular of inquiry, it has of course been impossible to weigh the evidence for exactly what it was worth. Some of it, as was to be expected, had to be thrown out altogether as coming from those who were not sufficiently observant to have distinguished between the new pest and its allies, also destructive to cabbages. To adopt indiscriminately all the data offered would lead to a chaotic result: we should be obliged for instance to say that the butterfly appeared in Ohio in 1865, when it had only that year crossed the northern border of New England; or that it reached central Illinois in 1871 or 1872, or even in 1859 when it had not yet been borne across the ocean; or that it appeared in Georgia in 1862 and was abundant there in 1866, some ten years before its time. More possibly correct is the nearly accordant testimony of no less than three reporters, whose judgment I have no means of testing; they agree in giving 1864 or 1865 as the date of the first appearance of the butterfly in eastern Pennsylvania and a fourth refers to it hesitatingly, perhaps as a matter of report; it is possible that it might have been brought across the ocean direct to Philadelphia at that date, but as it did not attract the attention of other entomologists in and about Philadelphia or make its impression on the country around, the supposition is rendered highly improbable; nor do the facts given above regarding its spread about New York lead us to admit that it reached that city from Philadelphia. It is far easier to suppose either that a mistake was made by each observer in the species concerned, or that the memory was at fault,—all these statements coming to me in answer to my enquiries last autumn; none of them are printed records. The point may perhaps be best solved by entomologists of that region, if they wish to follow it up; in which case the details in my possession will be furnished to any competent person.

I have not mentioned above a report made to me by an entomologist, Mr. George Bowles, whose specialty is Coleoptera, who states that when on a natural history expe-

dition to the West Indies and South America, he passed two days at the Island of Dominica, and there "observed the butterfly [*P. rapae*] along the edges of the canefields and in many parts of the town (Roseau), and I was told, it lived upon the mustard plant." This is an extract from his journal of February 23, 1884. In a subsequent letter he states that he is quite confident of his identification of the butterfly as it was very numerous and he had "paid particular attention to it in this country" from his interest in it through his cousin Mr. G. J. Bowles, who first brought it to notice in the Canadian Naturalist. Unfortunately all his collections, possibly including specimens of the butterfly seen, were lost by an accident on the Magazine River, British Guiana. Mr. Bowles gave me the addresses of persons in the Antilles who, he thought, might obtain specimens for me, and I have received replies from them, but as yet no autoptic evidence that *P. rapae* exists there, nor indeed anything to corroborate Mr. Bowles' belief, excepting from one gentleman who writes: "I have an idea I have seen the butterfly you mention, but am not certain." Enquiries are not yet closed, however.

In conclusion, it may be remarked that the definite setting down of territorial limits to each year's spread will naturally raise the question in the mind of every lepidopterist who examines the map, whether it rightly interprets the matter for the ground with which he is familiar. I beg therefore to ask those who see reason to question the accuracy of the lines at any point kindly to give me the benefit of their better knowledge, by exact and detailed statements; and, where possible, founded on something better than memory. Should a sufficient number of important divergences come to light, I will make them public in a formal statement. It may be stated, in a general way, that the lines are more conjectural in the southern states than elsewhere, owing to the paucity of observations.

Bibliography.

1. Bowles, G. J. On the occurrence of Pieris rapae in Canada. *Can. Nat.* n. s. I, 258–262. 8° Montreal, 1864. Separate, pp. 4.
2. Ritchie, A. S. Notes on the small cabbage butterfly, Pieris rapae. *Can. Nat.* n. s. III, 293-300. 8° Montreal, 1867. Separate, pp. 7.
3. Minot, C. S. Cabbage butterflies. *Am. Ent.* II, 76–77. 8° St. Louis, 1870.
4. Fitch, Asa. Cabbage worm or turnip butterfly. *13th Rep. Nox. Ins. N. Y.* (Ann. Rep. St. Agric. Soc.,) 543–563. 8° Albany, 1870.
5. Riley, C. V. Cabbage worms. *2d Ann. Rep. St. Entom. Missouri*, 104–110. 8° Jefferson City, 1870.
6. Bowles, G. J. Notes on Pieris rapae. *Can. Ent.*, IV, 102–105. 8°, London, 1872.
7. Bethune, C. J. S. Insects affecting the cabbage. *Rep. Ent. Soc. Ont.*, 1871, 82–88. 8° Toronto, 1872.
8. Packard, A. S. The imported cabbage caterpillar and its parasite. *2nd Ann. Rep. Inj. Ins. Mass.*, 8–11. 8° Boston, 1872.
9. Bethune, C. J. S. Cabbage butterflies. *Can. Ent.*, V, 41–43. 8° London, 1873.
10. Saunders, W. The English cabbage butterfly. *Rep. Ent. Soc. Ont.*, 1875, 31–32. 8° Toronto, 1876.

11. Walton, Alice B. The new cabbage butterfly. Read before the Muscatine Academy of Science, Nov. 3, 1879. 1 p. 4° n. p., n. d.
12. Hoffmeister, A. W. Report on noxious insects. *Trans. Iowa Hort. Soc.*, xiv, 82. 8° Muscatine, 1879.
13. Witter, F. M. Notes on Pieris rapae Schrank. *Proc. Musc. Acad. Sc.*, April 5, 1880. 2 pp. n. p., n. d.
14. Walton, Alice B. The cabbage enemy and remedies. *Trans. Iowa Hort. Soc.*, xiv, 23–24. 8° Muscatine, n. d.
15. Thomas, C. Cabbage insects. *9th Rep. St. Ent. Ill.*, 7–56. 8° Springfield, 1880.
16. Dodge, G. M. The cabbage butterfly, Pieris rapae, in Nebraska. *Rep. Ent. Soc. Ont.* 1882, 30–31. 8° Toronto, 1883.
17. Forbes, S. A. Experiments with the European cabbage worm. *12th Rep. St. Ent. Ill.*, 92–97. 8° Springfield, 1883.
18. Riley, C. V. Cabbage worms. *Ann. Rep. U. S. Comm. Agric.*, 1883, 107–138. 8° Washington, 1883.

IV. A Study of North American Geraniaceae.

By William Trelease.

(Read Feb. 16, 1887.)

In the following pages, I have brought together descriptions of our species of Geraniaceae, and a few biological notes on them, together with references on their pollination, dissemination, etc. No general revision of our species of this order has been undertaken since the publication of the first volume of Torrey and Gray's Flora of North America, 1838-40. The systematic literature and the synonymy of North American species will be found in Watson's Bibliographical Index to North American Botany, I, 149, while the more important papers on the order as a whole and its subdivisions are indicated in Bentham and Hooker's Genera Plantarum, I. A synopsis of the larger species of Geranium, by Engelmann, appears in Gray's Plant. Fendler., pp. 26-7.

I am indebted to Professor Gray and Mr. Watson for the free use of the Gray herbarium of Harvard University, and for many helpful suggestions; to Dr. Britton for the specimens contained in the Torrey and other herbaria of Columbia College; to Miss Carter for access to the herbarium of this Society; to Professors Prentiss and Dudley for the specimens in the Horace Mann herbarium of Cornell University, as well as for a large suite of duplicates of the eastern species; and to Dr. George J. Engelmann for forwarding me the specimens in the Engelmann herbarium of St. Louis. A number of friends have also favored me with smaller collections, chiefly of eastern species, the most valuable of these being a suite of specimens of *Oxalis recurva*, collected about Cincinnati, by Mr. C. G. Lloyd, and a Nuttall specimen of *Oxalis pumila* from Mr. J. H. Redfield, of Philadelphia, a fine suite of *O. Suksdorfii* from Mr. L. F. Henderson, of Portland, Oregon, and flowers from the type specimens of *O. Dillenii*, at Oxford, secured by Professor Gray.

GERANIACEAE, Bentham and Hooker, Genera, I, p. 269.

Annual, biennial, or perennial plants; ours herbaceous or merely suffrutescent. Leaves alternate or occasionally opposite or pseudo-verticillate, simple, divided, or compound, mostly cut-toothed. Inflorescence sometimes evidently cymose, or the flowers solitary

and terminal or apparently racemose or umbellate. Flowers hermaphrodite, mostly 5-merous (3-4-merous in *Limnantheae*) and symmetrical, nearly hypogynous. Sepals and petals distinct or nearly so. Stamens mostly twice as many as the petals, distinct or somewhat connate in *Oxalis* and *Impatiens;* anthers round-oval, more or less versatile, two-celled, dehiscing longitudinally. Carpels as many as the sepals, alternate with them and united about an axile column except in *Limnantheae;* ovary deeply lobed, its cells 1-∞-ovuled; styles commonly united below, the capitate or lateral stigmas mostly distinct. Glands of the receptacle as many as the sepals and opposite them (reduced and opposite the petals in *Oxalis*), or wanting when the flower is spurred. Seeds with little or no albumen except in *Oxalis;* embryo straight or incumbent, the cotyledons somewhat plicate and lobed in the genera with dissected leaves. A heterogeneous order of about 750 species, chiefly of subtropical and temperate regions, related on the one hand to *Zygophylleae*, and on the other to *Rutaceae.* The suborders are treated as distinct by many continental writers.

GERANIEAE[1].

Flowers regular or nearly so, 5-merous, homogone[2]; sepals imbricate, persistent, enlarging somewhat in fruit; petals imbricate, deciduous; antheriferous stamens as many as and opposite the sepals or twice as many, with persistent filaments; glands opposite the sepals, conspicuous; carpels alternate with the sepals, 2-ovuled, becoming 1-seeded, breaking elastically from a persistent fluted beak.—*Geraniaceae* of continental writers; five genera, three of them confined to Asia and Africa, the other two widely distributed.

GERANIUM, L. Gen., no. 673; Benth. and Hook., Gen., 1, 272.

Usually caulescent herbs with simple radiately-divided petioled and stipulate leaves; peduncles mostly 2-flowered; stamens ten, all antheriferous (except in *G. pusillum*), mostly united a little at base; ovary deeply divided; ripened carpels dehiscent on the inner side, the stylar appendage finally arched, glabrate on the inner side; seed round-oblong, smooth, reticulate-ridged, or hexagonal-pitted, with little or no albumen; embryo incumbent with sinuously folded cotyledons.—About one hundred species, almost confined to temperate regions.

Synopsis of North American Species.

*Perennial from a stout caudex; flowers large, 15-30 mm.; seeds reticulate-ridged. Erect, not cespitose; leaves large, 100-200 mm.

Petals glabrous or only pubescent within; plant scarcely glandular except that the calyx hairs are often tipped with small glands.

[1] The characters given refer only to our representatives.

[2] That is, essentially alike in a given species, so far as the relative length of stamens and pistils is concerned.

East of the Rocky mountains; calyx only moderately villous; pedicels canescent. . . . . *G. maculatum.*

Northwestern; calyx and usually pedicels very villous. . . *G. crianthum.*

Petals more or less villous within; at least the pedicels conspicuously glandular.

Stout; flowers purple; glandular hairs rather short, dirty yellow; tip of beak short and thick. . . . . *G. incisum.*

Slenderer; flowers mostly white; hairs long and white, tipped with purple glands; tip of beak longer and slenderer. . . . . *G. Richardsonii.*

More or less spreading and cespitose; leaves of medium size, 30–75 mm.

Upper leaves mostly as broad as long, with equal cuneate lobes.

Pedicels, etc., mostly glandular; filaments mostly about equalling the pistil. *G. Fremontii.*

Usually retrorsely canescent and not glandular; filaments a third longer than the pistil. . . . . *G. caespitosum.*

Upper leaves longer than broad, the terminal lobe longest, ovate-lanceolate. *G. Hernandezii.*

* *Annual or biennial; leaves seldom over 50 mm.; flowers smaller, 4–15 mm.; seeds smooth, reticulate, or pitted.

Carpels not bristle-bearing above; leaves radiately lobed or mostly dissected.

Peduncles mostly 1-flowered; leaves 3-cleft, with serrate divisions. . *G. Sibiricum.*

Peduncles 2-flowered; leaves several lobed.

Peduncles and pedicels long and slender; carpels subglabrous, not wrinkled; seeds deeply pitted. . . . . *G. columbinum.*

Peduncles and pedicels mostly short; carpels hairy or rugose.

Seed reticulate or pitted.

Pubescent or short-glandular.

Coarse; branches uniformly leafy; lobes of leaves rather broad and short; seed very low-ridged except in the variety. . . *G. Carolinianum.*

Slenderer; leaves crowded at the ends of the branches, their lobes long and narrow; seed deeply pitted. . . . . *G. dissectum.*

Glandular-villous with purple-tipped white hairs; leaves shallow-lobed; seed reticulate-ridged. . . . . *G. rotundifolium.*

Seed neither pitted nor conspicuously reticulate.

Carpels finely appressed-pubescent, not wrinkled; flowers pale; stamens five. *G. pusillum.*

Carpels subglabrous, transversely rugose; flowers deep purple; stamens ten. *G. molle.*

Carpels bristle-appendaged at the upper end, strongly wrinkled; leaves 1–2-ternately divided; very graveolent. . . . *G. Robertianum.*

1.[1] G. MACULATUM, L. Spec., 681. A foot to a foot and a half high, erect, subsimple, not cespitose, pubescent or canescent with spreading or mostly retrorse hairs, occasionally villous; leaves mottled, the radical mostly 2–4, long-petioled, suborbicular, incisely 3- or sometimes 5-parted, the divisions cuneate, the lower 2-cleft and all once to thrice 3-lobed at apex with abruptly acute or subacuminate coarsely acuminate-serrate lobes, basal sinus open, V-shaped; cauline leaves mostly two and opposite, occasionally alternate or sessile, otherwise like the radical; stipules oblong–elongated-triangular, entire or acutely 1–3-lobed near the apex; peduncles 1–5, mostly 3, umbellately clustered between the stem-leaves, simple or once or twice umbellately branched, the lateral frequently bearing single or paired reduced leaves; pedicels mostly paired, at length about an inch long, erect in fruit, retrorse-canescent; bracts linear, similar to the stipules; flowers large, rose-purple; sepals ovate-oblong, abruptly awned, the outer mostly villous and the inner ciliate; petals about 15 mm. long, woolly-ciliate at base; filaments somewhat ciliate; beak of fruit 25–35 mm. long, finely pubescent, abruptly narrowed above; styles free for 2–3 mm.; divisions of ovary sparingly close-pubescent and villous, 3.5–4 mm. long; seed finely reticulate-ridged, as in the rest of this section, 1.5 × 2 mm. —Open groves, Canada and New England to Saskatchewan and Missouri, south to Florida (*fide* Torrey & Gray, Fl. N. A.) and Alabama (Mohr, Prelim. List Pl. Ala.); common in the northern states. I have seen no specimens from farther south than Georgia and Kentucky.—Pl. 9, figs. 1–2; 10, fig. 4; 12, fig. 5.

2. G. ERIANTHUM, DC. Prodr., 1, 641. *G. maculatum*, β. Hook. Similar to the last, but more or less leafy-branched; leaves with more numerous narrower crowded lobes; pedicels scarcely over a half-inch long, erect in fruit, unequally canescent-pilose; calyx densely villous with long white hairs, many of them gland-tipped; petals purple, glabrous or minutely pubescent on the inner side; filaments long-pilose; beak 30-35 mm. long, canescent and somewhat villous, slender-tipped; styles free for 2–3 mm.; seed 1.5 × 3 mm.—Alaska and northwest British America; also in northeast Asia.—Pl. 9, fig. 3; 10, fig. 8.

3. G. INCISUM, Nutt., Torrey & Gray, Fl. N. A., 1, 206. *G. albiflorum*, var. (?) *incisum*, Torr. & Gr. *G. Hookerianum*, var. *incisum*, Walp. *G. viscosissimum*, Fisch. & Mey. *G. pentagynum*, Engelm.! *G. Fremontii*, Macoun, Cat. nos. 325–6. *G. erianthum*, Torrey, Bot. Wilkes' Exped., 251. Habit of *G. maculatum* but coarser, uniformly leafy-branched above, the branchlets subtended by more or less reduced leaves; pedicels and often petioles or even the entire plant dirty glandular-pubescent and somewhat unequally villous; leaves incisely 3- or mostly 5-parted, the lowest divisions again 2-cleft and all rather narrowly cuneate, basal sinus usually narrow, V-shaped or nearly closed; pedicels at last an inch or two long, the longest more or less refracted in fruit; flowers about as large as in *G. maculatum* and similarly colored; outer sepals glandular and somewhat villous; petals (within) and filaments sparingly white-villous; beak 35–45 mm. long, very glandular, short-pointed; styles free for 4–6 mm.; divisions of ovary glandular, 3 × 5 mm.; seed 2 × 3 mm.—Woods and open places, mountains of British America to Dakota and California.—Pl. 9, figs. 4–5; 10, fig. 11; 12, fig. 1.

[1] Only the numbered species belong to our flora as endemic or truly naturalized.

4. G. RICHARDSONII, Fisch. & Mey. Index Sem. Petr., IV, 37. *G. albiflorum*, Hook. *G. Hookerianum*, Walp. Similar to the last but slenderer, inconspicuously retrorse-pubescent below, the peduncles and pedicels villous with spreading white hairs tipped with purple glands; uppermost reduced leaves lanceolate, serrate but not lobed; pedicels more or less reflexed or spreading and bent in fruit; sepals canescent and somewhat glandular; petals purple (?) or mostly white, villous on the inner side like the filaments; beak 25–30 mm. long, sparingly fine-pubescent and villous-glandular; styles free for about 4 mm.; divisions of ovary 2 × 4 mm., pubescent and somewhat glandular-villous; seed 1.5 × 2.5–3 mm.—Open places and ravines in the mountains, Saskatchewan to New Mexico and Arizona; also found in California.—Pl. 9, figs. 6–8; 10, fig. 1.

5. G. FREMONTII, Torrey, Gray's Plant. Fendler., 26. More or less cespitose from a very stout caudex, a span to a foot or two high, the smaller plants sometimes subacaulescent, the larger with slender spreading leafy branches, somewhat canescent, the pedicels and often branches and petioles yellow-glandular; leaves typically closely appressed-pubescent and stout-veined, round-reniform, 3-parted with broadly cuneate divisions, the lower once or, especially on the radical leaves, twice cleft on the lower side; radical leaves usually with closed sinuses, the cauline similar or mostly truncate at base, with divergent lobes, all of which are incisely once or twice 3-toothed at apex with crenate-acuminate coarse teeth; pedicels at length an inch or two long, refracted in fruit; flowers rose-purple; petals 12–15 mm. long, emarginate, somewhat villous within; filaments pilose, equalling or exceeding the pistil; beak 25–30 mm. long, dirty glandular; styles free for 4–5 or even 6–8 mm.; divisions of ovary 2 × 4 mm.; sparingly hairy and glandular; seed 2 × 3 mm.—Mountains of Utah, Colorado, and New Mexico. Perhaps not distinct from the next and very closely related to the preceding. The larger form with conspicuously refracted pedicels is var. *Parryi*, Engelm., Amer. Journ. Sci. and Arts, third series, XXXIII, 405.—Pl. 9, fig. 9.

6. G. CAESPITOSUM, James, Long's Exped., II, 3 (?); Gray, Pl. Fendler., 25 (!). Similar to the last, but mostly longer stemmed and more decumbent and spreading from a shorter or slenderer caudex, canescent but not glandular, except on some pedicels of a few specimens; leaves less frequently truncate at base, with a more or less open sinus, their lobes narrower; peduncles long; pedicels mostly refracted in fruit; sepals long-pointed; petals smaller, 8–12 mm. long, scarcely emarginate, villous within; filaments bearded, conspicuously longer than the pistil; beak 25–35 mm. long, gray-pubescent, stout-pointed; styles free for 4–5 mm.; division of ovary more or less villous, sometimes with a few very short glandular hairs; seed 1.5 × 2.5–3 mm., reticulate.—Mountains, San Bernardino Co., California(?) (*S. B. Parish*, 1806), Arizona, New Mexico, and Texas, to Mexico.—Pl. 9, fig. 10; 10, fig. 6; 12, fig. 3.

There is reason to doubt whether James' plant was not really the preceding, for he did not collect south of Pike's Peak, while this species, as I understand it, is distinctively southern.

G. PRATENSE, L., of Europe, is reported by Fowler (Prelim. List of New Brunswick Plants, 20), as escaped from gardens near St. John, N. B. But it need not be described here.

G. Hernandezii, DC. Prodr., 1, 640. Perennial and cespitose (?), large and spreading, the lower nodes much dilated, loosely villous with often gland-tipped white hairs; radical and lower leaves 50–75 mm. across, on petioles nearly a foot long, 3-cleft, the basal divisions sometimes again lobed on the lower side, all ovate-oblong, cut-toothed or lobed towards the apex; upper leaves much smaller, deltoid-cordate, 3-parted, the divisions acute and serrate-lobed, the ovate-lanceolate middle one largest; peduncles not over an inch long; pedicels mostly shorter; sepals long-awned, the inner somewhat red-margined; petals white (?), half as long again as the calyx, spatulate, entire; filaments ciliate; styles free for about 2 mm.—Huachuca Mountains, southern Arizona (*Lemmon*, 2651). Apparently the same as Mexican specimens (*Schaffner*, 191), but not in fruit.—Pl. 9, fig. 11.

G. Sibiricum, L. Spec., 683. A slender-stemmed, repeatedly forked, short-villous, Asiatic annual, having 3–5-parted leaves with coarsely serrate, broadly lanceolate divisions; small, dirty-white, purple-veined flowers mostly solitary on bent pedicels an inch long, the 2-bracted peduncles of equal length or shorter; sepals awned; petals about 5 mm. long; beak canescent, 15–18 mm. long; the divisions of the ovary puberulent and sparingly villous, 2 × 4 mm.; seed 1 × 2 mm., minutely reticulate-areolate. Collected as a roadside plant on New York Island in 1867 (*Denslow*), and, as I learn from Doctor Britton, observed near the same place within a year or two. It was also collected on a refuse-heap, in Cambridge, in 1885 (*Morong*).—Pl. 9, fig. 12.

7. G. columbinum L. Spec., 682. Very slender-stemmed, spreading and prostrate, hispid with a close gray pubescence which is retrorse except on the leaves and sepals, not at all glandular; leaves more or less 3–5-divided and dissected into numerous linear divisions; stipules setaceous-pointed; peduncles very long; pedicels at length an inch or two long; sepals ovate, awned; petals purple, about equalling the calyx, spatulate, mostly eroded; beak 15–20 mm. long, with a long slender tip, appressed-hispid; styles free for about 1 mm.; divisions of ovary 2 × 3 mm., nearly glabrous, keeled on the back; seed subglobose, 1.5 × 1.75 mm., deeply pitted.—Pennsylvania (*Porter*), Virginia (*Curtiss*, *Pech*), Dakota (*Gratfeller*). Introduced from Europe, etc.—Pl. 9, fig. 17; 10, fig. 7; 12, fig. 9.

8. G. Carolinianum, L. Spec. 682. *G. atrum*, Moench. *G. lanuginosum*, Jaeq. A span to a foot high, stout-stemmed, spreading when large, loosely gray-pubescent and mostly dirty-glandular; leaves incisely 3–5-parted, divisions cuneate, more or less deeply cut-toothed or dissected into linear lobes; peduncles and pedicels seldom over an inch long, often densely crowded, the pedicels frequently somewhat bent in fruit; sepals ovate, acuminately tapering to a prominent awn, with recurved margins; petals rose-colored, about equalling the calyx, obovate, emarginate; beak about 20 mm. long, short-pointed, loosely villous or glandular; styles free for about 1 mm.; divisions of ovary 2 × 4 mm., not keeled, villous-hispid, when ripe mostly black; seed 1.25 × 2.25 mm., low-reticulate. —Open places, Canada to Washington Territory, south to Florida, California and Mexico; most common in the South and West.—Pl. 9, fig. 13; 10, fig. 2; 12, figs. 6-7.

Var. Texanum, collected near New Braunfels, Texas, by Lindheimer, in 1848, differs in having deeply pitted round seeds like those of *G. columbinum*, but with the habit and

foliage of *Carolinianum*. I have seen only a few plants, of a single collection, and have looked in vain for other characters by which this form can be separated, although the seeds indicate more than a varietal difference.—Pl. 12, fig. 8.

Var. LONGIPES, Watson, King's Rep., v, 50, of the mountains of Colorado and Utah, differs from the type in being of looser growth, with longer spreading peduncles and pedicels.

Bentham, in some instructive remarks on this species in Flora Australiensis, I, 296, regards it as only a form of the next, with which it certainly has much in common. While our plant is separated from the European *dissectum* without much difficulty, it must be admitted that Australian specimens are identical with those from the United States, with the exception that their clusters of fruit are mostly less dense and their roots perennial. Baron von Mueller, who for a time agreed with Bentham in referring the Australian form to *dissectum*, and once[1] called it *Carolinianum*, writes me that he has now adopted the name *G. pilosum* for it.

G. DISSECTUM, L. Amoen., IV, 282. *G. Carolinianum*, Gray, Proc. Am. Acad., VIII, 378. Very similar to the preceding, but the leaves rather more remote below, and, like the small pale flowers, clustered at the ends of the branches, their lobes longer and narrower; seed closely and rather deeply pitted.—Introduced into various places from Europe. I have seen specimens only from Oregon (*Hall*, 72) and Washington Territory (*Suksdorf*), but it is reported from various localities. Most of what has passed in America for this species is *G. Carolinianum*. Small specimens, like those of Hall, have much the habit of *G. pusillum*, but are distinguished by the seed.—Pl. 9, fig. 15.

G. ROTUNDIFOLIUM, L. Spec., 683, from Europe, resembling *G. Carolinianum* in its fruit and seed, and of nearly the habit of *G. pusillum*, but with the leaves short-lobed and the stem, etc., villous with long white hairs tipped with purple glands, has been collected in Michigan (*Farwell*) and on ballast about New York city (*Brown*).—Pl. 9, fig. 16; 10, fig. 9; 12, fig. 4.

9. G. PUSILLUM, L. Spec., 2 ed., 957. Slender-stemmed, spreading, soft-pubescent, or the calyx, etc., villous and usually glandular; branches leafy; leaves small, round-reniform or the cauline truncate at base, equally cleft into nine oblong or linear lobes each more or less regularly 3-toothed at apex; peduncles frequently opposite the leaves, short, like the pedicels; sepals ovate, acute or acuminate, not awned; petals pale purple, about equalling the calyx; fruit very small; beak about 10mm. long, short-pointed, puberulent; styles free for about 1 mm.; divisions of ovary 1 × 2mm., finely canescent, keeled, not wrinkled; seeds 5 × 1.4mm., smooth.—Open places, New York and Pennsylvania to Ohio; also reported from Canada (*Macoun*, Cat. III, 502); introduced from Europe. Five of the filaments are said to be constantly without anthers, as in *Erodium*.—Pl. 9, fig. 14; 10, fig. 3; 12, fig. 10.

G. MOLLE, L. Spec., 682, a very similar European plant, but readily distinguished by its dark flowers with ten antheriferous stamens, glabrous transversely wrinkled carpels, slightly striate seed, and longer soft pubescence, has been introduced in New York (*Sartwell*, *Knieskern*), Ohio (*Werner*), Washington Territory (*Suksdorf*) and Vancouver Island (*Macoun*); it is also reported in Ontario (*Macoun*, Cat., III, 502), and has

[1] Key to the System of Victorian Plants, II, 10.

been collected on ballast at New York City (*Brown*).—Pl. 9, fig. 18; 10, fig. 5; 12, figs. 13-14.

10. G. Robertianum, L. Spec., 681., *G. inodorum*, Don. A span to a foot and a half high, erect or spreading-decumbent, puberulent and loosely glandular-villous, purple-tinged, graveolent; leaves round-ovate, once or twice ternately divided, the ultimate lobes oblong, coarsely acuminate-toothed; stipules triangular, obtuse; pedicels half an inch or less in length, erect in flower and fruit; sepals ovate, lanceolate, long-pointed, connivent; petals rose-purple, 8-12 mm. long, spatulate, with long narrow claws; filaments glabrous; beak 20-25 mm. long, with a long slender point, minutely glandular-puberulent; styles free for about 1 mm.; divisions of ovary 1.5 × 2.5-3 mm., loosely wrinkled, sparingly pubescent, breaking away from the style with 2 long white apical bristles; seed 1 × 2 mm., smooth.—Damp ravines, etc., New Brunswick and Canada to New York, west to Minnesota and Missouri (*fide Tracy's List*); also found in Europe, Western Asia and North Africa.—Pl. 9, fig. 19; 10, fig. 10; 12, figs. 11-12.

Our Geraniums are annuals, becoming biennial, with the formation of a tap-root in some instances, or normally perennial, when they produce a larger or smaller rootstock which is considerably branched in one or two species. A number are weak-stemmed, and when these reach any considerable size they are decumbent, their enlarged nodes possessing the sensitiveness to gravitation which is characteristic of the swollen nodes of grasses[1], etc., which causes the stem to form abrupt geniculate bends at the lower joints. The pubescence consists of simple 1-celled pointed usually somewhat roughened hairs, frequently appressed and, on the lower part of the stem at least, retrorse, in a considerable number of species. Besides these there are in many species long, mostly spreading, white hairs, consisting of a long basal cell, and a single row of shorter cylindrical cells above. In *G. maculatum*, and especially *G. erianthum*, these, which abound on the calyx, often rendering it very villous in the latter, are tipped with rather small, purple glands, frequently rudimentary in the former. In *G. rotundifolium* and *G. Richardsonii*, though somewhat shorter and more rigid, they abound on the pedicels, etc., still preserving their white appearance; while in *G. Fremontii*, and especially *G. incisum*, they are of a dirty-yellow color. As a rule, hairs of this class appear to be pretty constant in their occurrence or absence in a given species; but some pedicels of *G. caespitosum* are nearly or quite destitute of glands, while others, even on the same plant, are evidently glandular-pubescent, and, judging from other plants, too much reliance should not be placed on characters derived from the pubescence. (Note 1.)

The inflorescence of *Geranium* is essentially cymose, the stem ending in a 1- or, mostly, 2-flowered peduncle, while lateral peduncles arise from the axils of the cauline leaves in simple plants of the *maculatum* type, their ultimate branches likewise ending in paired pedicels. In *G. maculatum* the lateral peduncles are sometimes more than 2, and bear reduced leaves, while in its western representatives they are regularly leafy and elongated, but otherwise similar. There is at first sight little to connect the more branched

[1] On *G. Robertianum*, see Rützou; Bot. Tidsskrift, XII; Just's Jahresbericht, IX, 420.

decumbent forms with this simple type, for their leaves are scattered and, in *G. pusillum*, etc., the 2-flowered peduncles are frequently opposite the leaves. But in *G. Sibiricum*, which is more or less regularly dichotomous, the forks are occupied by mostly 1-flowered peduncles, clearly the terminal shoots, and in the slender-stemmed species with the peduncles opposite the leaves the former are as certainly terminal, the leafy prolongation of the stem being in reality an axillary branch. (Note 2.)

The most interesting part of a biological study of *Geranium* is that relating to its pollination, and in this respect it has a historical interest, for it was the detection of tufts of hairs fringing the bases of the petals in *G. sylvaticum*, which led Sprengel just a century ago to examine the flowers closely in an effort, if possible, to determine their use, for he was utilitarian enough to believe that not even a hair grew without purpose. His study, carrying him farther than he had at first anticipated, led to the publication, in 1793, of a work which he quaintly styles the "Disclosed Secret of Nature," which not only contains much of scientific value, but is one of the most interesting biological treatises ever written, and, guiding the researches of Darwin, Müller, Delpino, and many other observers, has contributed not a little to the foundation on which the theory of evolution by natural selection rests.

No great attention has been given to the pollination of our American species; but, so far as they have been observed, the facts agree closely with those brought out by Müller's study of the same or related species in Germany, so I cannot do better than refer to his admirable account of the latter.[1] I may add that the larger-flowered species are conspicuously protandrous, their two sets of stamens becoming erect, and dehiscing successively at the centre of the flower, which, after their anthers have fallen, is occupied by the now expanded stigmas; while in the species with smaller, less conspicuous flowers, the duration of the staminate stage is much shortened, or, in *G. pusillum*, where the number of stamens with anthers is reduced one-half, the flowers are synaemic or slightly protogynous and certain of self-pollination if crossing is not secured.

The large-flowered species are, in the main, incapable of self-pollination, and depend exclusively (except in occasional synaemic flowers) upon the good offices of insects, chiefly bees of different kinds, which are attracted by the conspicuous petals, the veins of which point to an abundance of nectar, secreted by five prominent glands at the bases of the sepals. This is protected from inclement weather by tufts of hairs fringing the petals below, and, usually, from creeping insects like ants which cannot effectively bring about cross-fertilization, by the retrorse or glandular pubescence of the pedicels or stem. Doubtless the facility with which several of the small-flowered species gain a foothold in new countries is to be explained by their ability to self-fertilize where they are not visited by appropriate insects, as well as by their annual habit and abundant seeding. *G. Robertianum* alone, with narrower flowers contracted into a sort of tube, is adapted to pollination by long-tongued insects like the *Syrphidae*, which visit it freely in Europe, though I do not know that its American visitors have been recorded. (Note 3.)

The ripening carpels, as they dry, contract in such a manner that the outside is shortest, so that there is a tendency for their ends to bend outwardly; and, ultimately, after dehiscing along the ventral suture, they break away at the base and suddenly curve up-

[1] Fertilization of Flowers, p. 119.

wards with considerable force (Pl. 10). The segments of the ovary having already bent themselves at a sharp angle with the beak, the result of this movement is to throw the seed, or even the entire carpel, to a considerable distance. So far as I have examined them in the field, or as the indications of herbarium specimens are to be trusted, our species behave uniformly in this manner (though in *L. pusillum* the carpels do not bend abruptly above the ovary) with the exception of *G. Robertianum* (Pl. 10, fig. 10) and some of the other small-flowered species, where the ripened segments of the ovary, though nominally dehiscent, remain closed about the seeds, imprisoning them. To compensate for this, these segments nearly separate from the stylar appendages, with which, in *G. Robertianum*, they are finally connected only by a pair of slender silk-like bundles of fibres. When the style at length breaks away and suddenly becomes arched, these fibres give way and the ovarian segment with its enclosed seed is thrown off with much force, often to a distance of many feet. (Note 4.)

ERODIUM, L'Her., Geran. Pl. 1–6; Benth. and Hook. Gen., I, 272.

At length mostly caulescent, with often pinnatisect leaves; peduncles mostly umbellately several-flowered; flowers nearly regular, the upper petals a trifle smallest; stamens with anthers 5, opposite the sepals, alternating with as many sterile filaments; carpels very sharp-pointed below, covered with obliquely ascending appressed hairs, at most tardily dehiscent; styles spirally twisted below when ripe, bearded on the inner side; seed obconical or oblong, not sculptured; otherwise as in *Geranium*.—About fifty species, mostly natives of the north temperate portion of the Old World, some of them widely distributed as weeds.

Synopsis of North American Species.

*Leaves round-ovate, with approximated lobes, or not lobed; seed large, 4–5 mm. long.
Pedicels glandular, seeds stout. . . . . *E. macrophyllum.*
Not at all glandular, seeds slender. . . . . *E. Texanum.*

* * Leaves ovate-oblong, with approximate lobes; seed smaller, not over 3 mm. long.
Fruit very small, beak 25 mm. long. . . . . *E. malachoides.*
Fruit much larger, beak 70–120 mm. long.
Leaves pinnatifid with irregularly toothed segments. . . . *E. Botrys.*
Cauline leaves bipinnatisect with linear-oblong segments; sepals and fruit very large. . . . . *E. Ciconium.*

* * * Leaves oblong, with remote segments; seed as in the last.
Leaves pinnatifid, or bipinnatifid, with irregularly serrate segments; stipules obtuse. *E. moschatum.*
Leaves bipinnatisect, with narrow sharp-toothed segments; stipules acute. *E. cicutarium.*

1. E. MACROPHYLLUM, Hook. and Arn., Bot. Beechey, 327. Aspan to a foot or more high, branched when large, canescent-hispid and with copious interspersed glandular hairs, at least on the pedicels; radical leaves reniform, triangular-ovate, with a broad sinus, obtuse, doubly crenate or with about 5 round lobes; cauline leaves subdeltoid, incisely 5-lobed, with coarse round-acuminate teeth; lower petioles longer than the blades; stipules herbaceous, ovate, acuminate; peduncles mostly exceeding the leaves, 2–7-flowered, the pedicels somewhat refracted; bracts lanceolate; sepals ovate, with spreading acute or acuminate-pointed tips, usually scarious-margined, purple-veined, at length 12–15 mm. long; petals 10–15 mm.; beak finally 40–50 mm. long; divisions of ovary more densely hairy than in our other species, conspicuously truncate, 3 × 9 mm.; seed 1.5 × 4.5 mm. —Texas to California.—Pl. 10, fig. 12.

2. E. TEXANUM, Gray, Pl. Lindheimer, 157. *E. macrophyllum*, Gray, Ives' Rep. 8. Very similar to the last but not at all glandular; pedicels and flower-buds silvery canescent; leaves triangular-cordate, with a broad sinus, obtuse, 3-parted, the cauline often with sinuses widened below, the basal divisions mostly cleft on the lower side and the terminal trilobed; sepals abruptly acuminate-pointed, 8–12 mm. long; petals purple, 15–18 mm. long, sometimes greatly reduced or wanting; beak 50–70 mm. long; divisions of ovary not prominently truncate, 1.5–2 × 9 mm.; seed .8–1 × 3.7–4 mm.—Texas to California.—Pl. 10, fig. 13.

E. MALACHOIDES, Willd., Spec. III, 639, a somewhat glandular, small-flowered plant, with ovate somewhat incisely 5–9-lobed irregularly toothed leaves, short-pointed sepals about 5 mm. long, and very small fruit, the beak 25 mm. long, divisions of ovary 1 × 4 mm., obliquely truncate, seed .8 × 2.5 mm., has been collected on ballast at New York City (*Brown*).—From the Mediterranean region.—Pl. 10, fig. 14.

E. BOTRYS, Bertoloni, Amoen. Ital., 35, with loosely white-villous stems and petioles, incisely 5–9-parted ovate-oblong leaves, the cauline with rather narrow acute divisions, thin ciliate stipules, pointless sepals 8–9 mm. long, and large fruit, the beak 70–120 mm., and scarcely truncate divisions of ovary 1.5 × 11 mm., has been collected in the Sacramento Valley, California (*Greene*) and on a refuse-heap in Boston (*Murray*).—From South Europe.—Pl. 10, fig. 16.

E. CICONIUM, Willd., Spec. III, 629, with glandular somewhat canescent stems, ovate leaves, the cauline bipinnatisect, abruptly awn-pointed sepals at length 8–10 mm. long, and large fruit, the beak over 70 mm., divisions of ovary 2 × 9 mm., has been collected on ballast at Philadelphia (*Martindale*).—Also from the Mediterranean region.—Pl. 10, fig. 15.

3. E. MOSCHATUM, Willd., Spec. III, 631. Villous with coarse thin-walled spreading hairs; leaves oblong, pinnately divided, divisions 9–13, the lower remote, ovate, incisely lobed or irregularly biserrate; stipules ovate-deltoid, thin and scarious, obtuse; sepals abruptly mucronate, 8–10 mm. long; petals rose-colored, 3–5 mm. long; beak 40–45 mm.; divisions of capsule 1 × 4 mm., obliquely truncate; seed 1 × 2.5 mm.—California to Mexico, becoming a common roadside weed. A native of the Mediterranean region, also introduced into South America and Australia. Said to give an unpleasant taste to milk and butter when eaten by cattle. The form with rather deeply cut leaf segments approaches var. *pimpinellaefolium*, of the next.—Pl. 10, fig. 17.

4. E. CICUTARIUM, L'Her., Ait. Hort., Kew, II, 414; Brewer and Watson, Bot. Calif. I, 94; Vasey, Rep. Depart. Agric., 1881–2, 253, Pl. 22. Loosely white-villous; leaves oblong, pinnately 9–11-divided; divisions remote, ovate, pinnatisect with oblong or linear sharply serrate segments; stipules scarious, lanceolate, acute; peduncles about 9-flowered; sepals about 8 mm. long, mostly abruptly pointed, the awn tipped with 1–2 long white hairs; petals rose-purple, about 5 mm. long; beak 30–40 mm.; divisions of capsule 1 × 5 mm., obliquely truncate; seed .8 × 2.5–3 mm.—Oregon to Nevada and Texas; also met with occasionally as a weed or ballast-plant elsewhere (Mich., *Tuthill, Bailey;* Mass., *Murray, Lowell, Oakes;* Maine, *Farlow;* New York, *Knieskern, Holton;* Pennsylvania, *Redfield;* New Jersey, *Parker;* New Brunswick, *Hay*). Introduced from south Europe. Flowering in dry places when less than an inch high. Relished by cattle, and said to impart a pleasant taste to their milk.—Pl. 10, fig. 18.

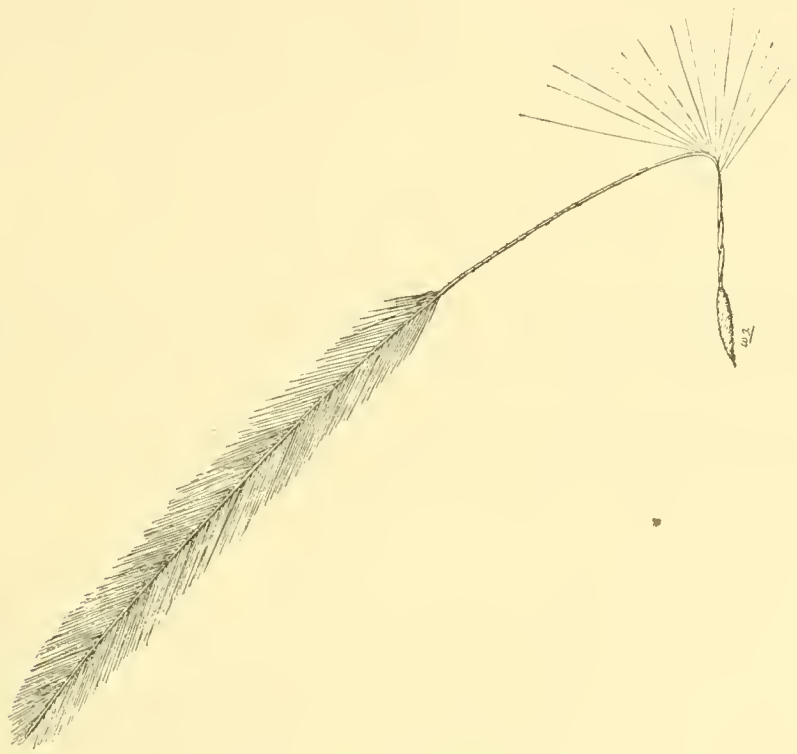
So far as their vegetation is concerned, the species of *Erodium* agree in the main with *Geranium*. As a rule they are less branched. (Note 5.) The inflorescence differs chiefly in that the umbels are more than 2-flowered, and the pedicels are always more or less reflexed during the maturation of the fruit, to become erect, ultimately.

The flowers are usually turned more to one side when open, than in *Geranium*, and this change in their position is accompanied by a slight degree of irregularity, the two or three petals on the lower side being larger, by which they are fitted to serve as an alighting place for insect visitors—chiefly bees. The flowers are usually distinctly protandrous, and secrete an abundance of nectar. In the main they differ very little from those of *Geranium* in the way in which they are pollinated. *E. cicutarium* has been shown by Ludwig to be gyno-dioecious. (Note 6.)

The contrivances for dissemination are even more interesting in this genus than in the last. The fruit is essentially the same in both, the segments of the ovary being prolonged in flat bands that extend along an axile beak and form the styles above. These appendages or awns consist in both genera almost exclusively of mechanical (bast) fibres. In *Geranium*, those forming the outer part contract to a greater extent than those nearer the axis, as the fruit ripens, so that ultimately the base of the awn curves outwards in a radial plane, as has already been explained. In *Erodium* the carpels remain practically indehiscent and are firm and sharp-pointed at the base, gradually enlarging upwards, and are covered below with obliquely ascending stiff hairs, supported at the base by firm cells projecting from the epidermis of the ovary. The awn is similar to that of the last genus, but while its outer fibres merely shorten in drying, the inner ones, for the lower half, contract spirally, so that the ripened carpel is not only thrown elastically from the plant, but the awn ultimately becomes coiled below into a close helix, from the top of which the upper half bends away in a gradual curve. The awn is also bearded below, on the inner side, and when it at length becomes twisted, the long loose hairs point outwardly in such a manner as to act in some measure as a parachute, favoring the further removal of the fruit by the wind.

When moistened, the awns become straight, resuming their coiled form again when allowed to dry, and repeating these changes with every alternation of moisture and dry-

ness. Supposing the basal point of the carpel to be slightly caught in the soil, which readily happens either as the fruit falls or when its movements begin, its withdrawal is rendered difficult by the stiff ascending hairs with which the ovary is clothed; so that while the crowding of the awn against bits of stubble, pebbles, or whatever small objects it may chance to have fallen among, tends to press the fruit farther into the earth with every movement, whether the result of moistening or drying of the awn, the probability of its withdrawal, when once caught, is small. In some experiments performed in my laboratory several years since, by Mr. E. H. Parker, it was observed that after the fruit had been buried in damp soil for a few days, the awn softened at its base, so that a pull, which otherwise might have withdrawn the fruit, merely broke away the awn,



Fruit of *Erodium glaucophyllum*, × 2.

thus removing the only source of danger to the self-planted seed, a provision which was also noticed in *Stipa*, and has been recorded for these genera by Roux and Darwin respectively.

The contrivances in the fruit, therefore, are of a double nature, referring not only to its removal from the parent plant, but to its insertion in the soil when a suitable point has been reached. It is interesting to note that similar provisions are met with in widely separated genera (*Anemone* § *Pulsatilla*, and species of *Stipa* and *Aristida*), not at all related to *Erodium;* as well as in *Pelargonium*, a genus which stands very near the latter, the fruit of which is less elastic, and consequently more dependent upon the wind for dissemination, although it is ultimately planted in the same manner.

Our species of *Erodium*, including those which have become naturalized or are merely occasional ballast-plants, belong to the section with the arched upper half of the awn naked or at most short-pubescent; but in another section, represented by *E. glaucophyllum* and several other species, this appendage is much elongated, and plumose with a double series of long silken hairs. There can be little doubt that the carpels of species of this section are carried about freely by the wind, while they may at length be planted by the coiling and uncoiling of the lower part of the awn, as in the species already described. This may also be expedited by the action of the wind upon the plumed awn, after the fruit has once caught in the soil, as I have convinced myself by grasping the ovary between my thumb and finger, and blowing irregularly upon the plume; the result in every instance being to crowd the ovary down several millimeters in a short time. (Note 7.) Here again it is interesting to observe an identical contrivance in *Stipa pennata* and related species, which differ from others of the genus in possessing a long-plumed awn.[1] *Monsonia*, a close relative of *Erodium*, likewise includes species with plumed and plumeless fruit.

LIMNANTHEAE.

Flowers regular, very slightly perigynous, 3–5-merous, homogone; sepals valvate, persistent and somewhat enlarged in fruit; petals convolute or open, withering-persistent; stamens twice as many as the sepals, all with anthers; glands opposite the sepals, evident; carpels opposite the sepals, their 1-ovuled ovaries distinct, the style rising from the centre; fruit a series of semi-drupaceous rugose-tuberculate nutlets.—*Limnanthaceae* of continental writers; two genera, exclusively North American.

LIMNANTHES, R. Br., London and Edinb. Philos. Mag., II, 70; Benth. and Hook., Gen., I, 274.

Rather succulent annual herbs with alternate once to thrice pinnately dissected petioled mostly estipulate leaves; flowers solitary at the ends of bractless axillary peduncles, 4- or mostly 5-merous; petals obovate-cuneate, mostly emarginate, convolute; filaments distinct, somewhat dilated at base, their tips at first recurved outwards; anthers at length introrse; style about equalling the stamens; seed exalbuminous, closely invested by the pericarp; embryo straight, with plane cotyledons. *Floerkea*, Baillon, Adansonia, x, 362; Hist. des Pl., v, 20, in part.—Four species, confined to the Pacific slope.

1. L. ALBA, Hartweg, Benth., Pl. Hartw., 301. A span or two high; young leaves and flower-buds very white-lanose; leaves remotely 5–9-divided, the divisions linear-oval, mostly 10–15 mm. long, entire, 3-lobed or trifid; sepals ovate-lanceolate, acute or acuminate; petals pale yellow or white, emarginate or truncate, 10–12 mm. long; stamens about

[1] The experiments of Mr. Parker with this grass (which consisted in barely starting the point of the fruit in loose earth, and placing it where the air from a slightly opened window blew upon it intermittently) demonstrated that this force alone is sufficient to bury the grain completely in sandy soil within twenty-four hours, while the hygroscopic action of the lower part of the awn is also efficient. See, further, Lubbock, Rept. Brit. Assoc. 1881, 668.

half as long as the petals, anthers 2 mm. long; fruit obovoid-pyriform, prominently rugose-tuberculate, 2.5 × 4 mm.—California. A low plant, with petals no longer than the sepals, is found near Yreka by Greene.—Pl. 12, fig. 19.

2. L. Douglasii, R. Br., *l. c.* *Floerkea Douglasii*, Baillon, *l. c.* Glabrous; sepals narrower; petals deep yellow, pale-margined, occasionally rosy tipped, conspicuously veined, spatulate-cuneate and emarginate, to obcordate-cuneate; fruit varying from nearly smooth to strongly tuberculate; otherwise like the last.—California to Oregon.—Pl. 12, figs. 16–17.

3. L. rosea, Hartweg, Benth., Pl. Hartw. 301; Brewer and Watson, Bot. Calif. II, 438. Very similar to *L. Douglasii;* leaf-lobes usually narrower and linear; petals mostly broader and, like the stamens, marked by numerous very delicate interrupted longitudinal rose-purple lines; fruit very rough.—California. Perhaps no more than a variety of the last. Flowers heliotrope-scented.

4. L. Macounii, n. sp. *Floerkea proserpinacoides*, Macoun, Rept. Geol. Surv. Canada, 1875–6, 192; Cat. Can. Pl. I, 91, in part. *Limnanthes Douglasii*, Macoun, Cat. III, 502. Glabrous, 2–3 inches high; divisions of the leaves 5–9, remote, 3–6 mm. long, ovate, mostly 3-cleft, their lobes broad and very acute; flowers 4-merous, not showy as in the other species; sepals oblong, rather obtuse, enlarging somewhat in fruit; petals white(?), oblong-cuneate, erosely truncate, 3–4 mm. long; stamens about equalling the petals, anthers .4 mm. long; fruit obovoid, 3 mm. long, with very prominent tubercles. —Vancouver Island (*Macoun*). Collected only once, in 1875.—Pl. 12, fig. 18.

FLOERKEA, Willd., Neue Schr. Gesellsch. naturf. Fr., Berlin, III, 448; Benth. and Hook. Gen., I, 275.

Flowers 3-merous; petals oblong, entire, shorter than the sepals, open in aestivation; otherwise as in *Limnanthes*, which, as Baillon, Eichler, and others have shown, is much too close.

1. F. proserpinacoides, Willd., *l. c.* *F. lacustris*, Pers. *F. palustris*, Nutt. *F. uliginosa*, Muhl. *Cabomba pinnata*, Röm. and Schult. *Nectris pinnata*, Pursh. Glabrous, weak-stemmed, a span to a foot high; divisions of the leaves mostly 5, lanceolate or occasionally elliptical, 10–15 mm. long, remote; flowers very inconspicuous; sepals ovate, acute, enlarging in fruit; petals white, 1–2 mm. long; stamens about equalling the petals, anthers .2 mm. long; fruit subglobose, loosely tuberculate above, 3–4 mm. long.—Rich, damp woods, Canada and New England to Oregon and California; south to Pennsylvania and Missouri.—Pl. 12, fig. 20.

The Limnantheae do not appear to have been much studied from a biological standpoint. In the large-flowered species the abundance of nectar is advertised by a pronounced fragrance as well as by the color of the corolla, the veins or striae of which also serve as nectar-marks. They are said to be much visited by bees, and are clearly

adapted to pollination by these insects. Darwin[1] has shown that the flowers are fertile with their own pollen. *Floerkea* and, apparently, *Limnanthes Macounii*, with smaller, inconspicuous flowers, are apparently adapted to pollination by small bees and are likely to be found fully self-fertile, but no observations have been made on them. The seeds of both genera are enclosed in integuments consisting of brown, rather thin-walled cells, the outer and inner layers of which are collapsed and closely surrounded by the indehiscent, rugose-tuberculate pericarp, which is soft, and consists externally of thick-walled, rather pale cells, some of which, on the outside, develop into thick-walled, verrucose, rounded papillae. I am unable to offer any suggestion concerning their dissemination, or the use of the peculiar roughening of the pericarp. (Note 8.)

OXALIDEAE.

Flowers regular, 5-merous, homogone or heterogone; sepals imbricate, persistent; petals convolute, distinct or somewhat united near the base, deciduous; stamens twice as many as the sepals, sometimes with an additional set of auricles or sterile scales; glands greatly reduced or wanting, alternate with the sepals when present; carpels alternate with the sepals. *Oxalideae* of continental writers.—Five genera, three of them confined to tropical Asia, one South American, the other widely distributed.

OXALIS, L. Gen. n., 382; Benth. and Hook. Gen., 1, 276.

Annual or perennial often bulbiferous herbs, sometimes suffruticose or frutescent, with compound petiolate mostly estipulate leaves; stamens ten, monadelphous below, in two sets of different length, all antheriferous; ovary somewhat lobed, forming a loculicidal capsule tipped by the persistent distinct styles; seed with a longitudinally-dehiscent arilloid outer coat, the firm more or less viscid inner integument usually sculptured; embryo straight, with plane cotyledons, in abundant albumen. *Oxys* of older writers.—About 220 species, mainly in South America and Africa.

Synopsis of North American Species.

*Caulescent; flowers yellow, sometimes, like the rest of the plant, tinged with red-purple.

Leaves unifoliolate, with free setaceous stipules . . . *O. dichondraefolia.*

Leaves pinnately trifoliolate, estipulate . . . . . *O. Berlandieri.*

Leaves palmately trifoliolate, estipulate or with short adnate stipules; leaflets subsessile, more or less obliquely obcordate-cuneate.

Leafy branches from a stout woody caudex. . . . . *O. Wrightii.*

[1] Cross and Self-fertilization, Index.

Stems not from a caudex, but mostly perennial from slender rootstocks.

Flowers usually small, homogone, the styles about equalling or longer than the longest stamens . . . . . *O. corniculata.*

Flowers large and showy, heterogone or appearing so.

Repent, with adnate stipules; flowers doubtfully trimorphic. *O. corniculata*, var. (?) *macrantha.*

Erect, stipules none; flowers clearly trimorphic.

Low, slender-stemmed; leaflets not margined (Oregon). *O. Suksdorfii.*

Tall and rather stout, leaflets dark margined (Middle States). *O. recurva.*

* * Acaulescent; leaves and scapes from the end of a slender perennial scaly rootstock; flowers white or pinkish, somewhat yellow at base and mostly red-veined, homogone; leaves palmately trifoliolate.

Scapes 1-flowered; capsule round-ovoid . . . . . *O. acetosella.*

Scapes umbellately several-flowered; capsules linear . . . *O. trilliifolia.*

* * * Acaulescent; leaves and scapes from a scaly bulb; flowers heterogone, rose-violet; leaves palmately 3-10-foliolate; sepals (and usually leaflets) tipped with orange callosities.

Leaflets constantly 3.

Obcordate or transversely lunate-oblong; capsule round-ovoid . *O. violacea.*

Obcordate-deltoid; capsule linear-oblong . . . . . *O. latifolia.*

V-shaped; capsule ovoid-oblong . . . . . *O. vespertilionis.*

Leaflets 3–5 (mostly 4), deeply obcordate . . . . . *O. divergens.*

Leaflets 5–10, narrow, deeply notched, bilobed, or Y-shaped . *O. decaphylla.*

1. O. DICHONDRAEFOLIA, Gray, Pl. Wright., I, 27. Caulescent, a span to a foot high, perennial, appressed-pubescent; branches spreading or procumbent, woody and rough-barked at base; leaves unifoliolate, leaflet round-ovate, wavy-margined, cordate, abruptly depressed and mucronate at apex, 12–30 mm. long; petiole as long, or somewhat exceeding it; stipules setaceous, free from the petiole, often 10 mm. long; flowers homogone (?), 12 mm. long, solitary on axillary peduncles equal to or surpassing the leaves, and with two setaceous bracts near the summit; sepals triangular-lanceolate, acute, dilated at base; petals spatulate, entire, submucronate and slightly ciliate above, half as long again as the calyx; capsule round-ovoid, 10 mm. long, pubescent; seeds about three in each cell, with prominent tubercles arranged in transverse, more or less oblique rows, 1.4 × 2.2 mm. — New Mexico (*Wright*) and Texas (*Berlandier, Wright, Palmer, Reverchon*) to Mexico. —Pl. 11, fig. 1.

2. O. BERLANDIERI, Torrey, Bot. Mex. Bound., 41. Caulescent, a span or less high, perennial "from a slender subterranean rhizoma," somewhat woody below and much branched, gray- or rusty-pubescent; leaves pinnately trifoliolate, estipulate, on petioles about 15 mm. long; terminal leaflet obovate-oblong, 10–15 mm. long, on a stalk half as long, lateral ones smaller, opposite, oblong, very short-stalked, all obliquely emarginate at apex, nearly glabrous above; flowers heterogone (?), about 12 mm. long, umbellate at the ends of axillary peduncles about equalling the leaves; umbels mostly 3-flowered; pedicels usually shorter than the flowers; sepals lanceolate, acute; petals obovate, suben-

tire, thrice as long as the calyx; capsule ovoid, about 5 mm. long, pubescent; seeds 1–3 in each cell, fusiform, somewhat flattened, with 8 prominent longitudinal zigzag wings or rows of teeth, .8 × 1.6 mm.— Texas (*Berlandier*, 1094, 2524, *Boundary Commission, Schott*, 149); not collected recently.—Pl. 11, fig. 2.

3. O. WRIGHTII, Gray, Pl. Wright., I, 27. Caulescent, perennial from a stout, conical, subterranean caudex, at the apex of which the decumbent leafy branches are clustered, otherwise very similar to the next.—Arizona and Indian Territory to Texas, extending into lower California and Mexico. An Arizona specimen (*W. F. Parish*, 32) is densely gray-tomentose below.—Pl. 11, fig. 3.

4. O. CORNICULATA, L. Spec., 435. *O. pusilla*, Salisb. Caulescent, an inch to a span or more high, annual or perennial, slender-stemmed, erect or procumbent, in some forms rooting at the nodes, gray or rusty strigose-pubescent; leaflets 3, obcordate, broader than long, 10–15 mm. wide, the long slender petioles dilated below the basal pulvinus into round or truncate ciliate stipules; flowers 5–8 or in some forms 12 mm. long, solitary or usually paired, on bibracteate peduncles equal to or exceeding the leaves; pedicels mostly longer than the flowers, reflexed in fruit; sepals oblong, rather obtuse; petals obscurely crenulate or emarginate, about twice as long as the calyx; styles about equalling the long stamens, or, in larger-flowered specimens, exceeding them; capsule erect, oblong, 10–20 mm. long, strigose; seeds about ten in each cell, but varying greatly in number, ovate, acute above, much flattened, with 1–3 deep marginal grooves and numerous transverse ridges somewhat interrupted by two low longitudinal elevations on each side, .8–.9 × 1–1.5 mm., mostly dark brown when ripe.—Over the entire country; flowering through the season. A cosmopolitan weed with many forms, several of which have received specific names, but are now generally united.—Pl. 11, fig. 4.

Var. (?) MACRANTHA. Decumbent from a stout or slender horizontal rootstock, the branches erect, a span high, pilose with spreading pointed hairs; leaflets narrower; flowers pale, 10–15 mm. long, extremely variable in the relative length of stamens (or perhaps heterogone-trimorphic), otherwise as in the type.—Arkansas to Texas and along the Gulf to Florida; also in California.—Pl. 11, fig. 5.

Some plants are very similar to specimens from Australia referred to *O. microphylla* (now regarded as a variety of *corniculata*), but are not the form usually known by that name. If the flowers are truly trimorphic this will have to be separated from *corniculata*. It may possibly be *O. pilosa*, Nutt., of which I have seen only a fragmentary fruiting specimen, and is apparently *O. pumila*, Nutt., which I have seen from the Torrey herbarium and that of the Philadelphia Academy, through the courtesy of Doctor Britton and Mr. Redfield, so that if it is ever raised to specific rank it will have to bear the latter name.

Var. STRICTA, Sav., Lam. Dict., IV, 683. *O. stricta*, L. and most authors. *O. Dillenii*, Jacq. *O. florida*, Salisb. *O. Lyoni*, Pursh. *O. furcata*, Elliott. Annual, or often perennial by running rhizomes, erect, a span to a foot high, the stem subglabrous to very villous, but usually only slightly strigose; leaves without stipules; inflorescence in luxuriant specimens a dichotomous cyme, in others umbellate; flowers about 8 mm. long; petals subentire; otherwise similar to the type and of like distribution, but beginning to flower later. According to Eichler the first flower is frequently 6-merous.

Jacquin, whose illustrations otherwise well represent our extreme form of *O. corniculata* and its variety *stricta*, figures the former without stipules, and the latter with rounded stipules, while the reverse is true.[1] Elongated acute stipules, such as Salisbury[2] and Sowerby[3] figure, have not been observed in our specimens, but can readily be conceived as resulting from the prolongation of the acute outer angle of such truncated stipules as some of our plants possess. The pubescence of most forms of this species consists of spreading or appressed unicellular pointed hairs, with thick verrucose walls, intermingled with which are a very few blunt hairs consisting of a single row of smooth, thin-walled cells. In var *stricta* the pointed rough hairs are abundant on the leaflets, pedicels, etc., but they are commonly less numerous on the lower part of the stem and petioles. Where these are hairy (and they are extremely villous in some plants growing in shaded places), the pubescence often consists almost exclusively of the thin-walled hairs, which are often of unusual length, and easily show their septate character under a hand-lens; the same is sometimes true of the capsules.

5. O. Suksdorfii, n. sp. *O. corniculata*, Gray, Proc. Amer. Acad., viii, 378. Perennial from a slender creeping rootstock, slender-stemmed, erect, a span or two high, more or less pilose, or loosely villous; leaves estipulate, long-petioled, trifoliolate, leaflets deeply obcordate, with unequal lobes as much as 25 mm. wide; flowers mostly paired on long axillary peduncles, heterogone-trimorphic, bright yellow; bracts subulate; sepals obtuse, downy; petals thrice as long as the calyx, 15 mm. long, wavy-margined, not emarginate. Fruit not seen, but presumably as in *O. corniculata*.—In woods; Oregon (*Nuttall, Hall, Henderson, Suksdorf*); collected in June by Mr. Suksdorf.

6. O. recurva, Elliott, Bot. S. Car. and Georgia, i, 526. Annual (?) or perennial from a slender rootstock, erect, simple, 1–2 ft. high, glabrate or somewhat soft-villous; leaves long-petioled, estipulate; leaflets large, as much as 60 mm. wide, broadly obcordate with a shallow sinus, somewhat pubescent and ciliate, narrowly margined with brown-purple; flowers umbellate or subcymose, 12–15 mm. long, yellow, brown-striate at base, heterogone-trimorphic; otherwise similar to *O. corniculata*, var. *stricta*.—Open woods, etc. Carolina (*fide Elliott*), to Pennsylvania (*Carey*), west to Ohio (*Lea, Lloyd*) Indiana (*fide Barnes*, Bot. Gaz., ii, 21) and Tennessee (*Gattinger*). Flowering from May to June or the early part of July.—Pl. 11, fig. 6.

Elliott based his description on the short-styled plant, which he says is "very common near Charleston, intermingled with *O. stricta*, with which it has been confounded." Carey, whose specimens, so far as I have seen them, were all long-styled, regarded it as *O. Dillenii*, from which, however, it is quite distinct, judging from the figure, in Dillenius's Hort. Ethel., ii, Pl. 221, on which the latter is based, and a single flower of the original of the figure, kindly secured for me, at Oxford, by Dr. Gray. Lea, who appears to have studied it carefully about Cincinnati, contributed a suite of specimens, representing the three forms of flowers, to Torrey, but was apparently misled into considering the length of stamens and pistil merely variable, trimorphic heterogony not having then been discovered. I am indebted to Mr. C. G. Lloyd for a suite of specimens from the vicinity of Cincinnati.

[1] Oxalis Monogr., Pl. 4–5.

[2] Trans. Linn. Soc., ii, Pl. 23, fig. 5.

[3] English Bot , Pl. 1726; Third ed., Pl. 321.

7. O. ACETOSELLA, L. Spec., 433. *O. Americana*, Bigel. *O. Montana*, Raf., Annals of Nature, 1, 12. Acaulescent, perennial by a slender simple or sparingly branched rootstock, more or less rusty-pubescent; leaves few (usually 3–6) a span or less high; petioles slender, articulated with their dilated bases, that persist on the rootstock clustered at the end of each year's growth; leaflets 3, broadly obcordate, with a minute appendage in the narrowed base of the sinus; scapes solitary or few, slightly exceeding the leaves, 1-flowered, 2-bracted about an inch below the flower; bracts broad and rather obtuse; flowers open cup-shaped, 10–15 mm. long, homogone (but usually appearing as if the long-styled form of a trimorphic species); sepals ovate-oblong, rather obtuse; petals 3–4 times as long as the calyx, emarginate; capsule subglobose, 2–3 mm. long, its cells 1–2-seeded, glabrous; seeds ovoid, acute above, with about 5 shallow longitudinal grooves on each side, and obscurely pitted.—Damp woods from the mountains of North Carolina far northward, where it ranges from the Atlantic to the Saskatchewan. Also found in Europe, Asia and North Africa. Recurved scapes bear cleistogene flowers, mostly concealed among the moss, etc., at the base of the plant.—Pl. 11, fig. 7. A form with deeper-colored flowers found in New Brunswick, etc., is var. *subpurpurascens*, DC. Prod. 1, 700.

Var. OREGANA. *O. Oregana*, Nutt. in Torrey and Gray, Fl. N. Am., 1, 211. *O. acetosella*, Hook., Fl. Bor.- Amer. 1, 118. Larger in every way and more rusty-pubescent, as much as a foot high and with leaflets in extreme cases over 40 mm. long; flowers 20-25 mm. long; capsules 10 mm.; seeds 2.5 × 3.5 mm.; otherwise as in the type.—California to Washington Territory. The description of fruit and, in part, of inflorescence, in Botany of California, 1, 96, relates to the next species.—Pl. 11, fig. 8.

8. O. TRILLIIFOLIA, Hook., Fl. Bor.-Amer., 1, 118. *O. macrophylla*, Dougl. in Hook. *l. c.* *O. Oregana*, Brewer and Watson, Bot. Calif., 1, 96, in part; Gray, Proc. Amer. Acad. VIII, 378. Habit of the last, sparingly pubescent or glabrate; leaves a span to a foot high, leaflets 25–45 mm. long and usually about as broad; scapes mostly several, a little longer than the leaves, umbellately about 6-flowered; pedicels at length equalling the capsules; bracts acute; flowers small, 5–12 mm. long, homogone; petals deeply emarginate or bifid and nearly white; capsule linear, 25 mm. long, its cells about 6-seeded, glabrous; seeds red-brown, oblong, obscurely coarse-pitted and somewhat longitudinally striate, 1 × 2.2 mm.—Damp woods, Washington to Oregon.—Pl. 11, fig. 9.

9. O. VIOLACEA, L. Spec. 434. *O. longiflora*, L. *O. pulchella*, Salisb. Acaulescent, perennial from a stout brown bulb with rusty-ciliate scales, glabrous or the pedicels and bases of the leaves glabrate; leaves several from each bulb, a span or less high, leaflets 3, about 10 mm. long, broadly obcordate with an open sinus, the midrib tipped on the lower side with a pair of usually prominent confluent orange callosities[1]; scapes several, mostly about twice as long as the leaves, umbellately 3–12-flowered; pedicels at length rather longer than the flowers; bracts acute; flowers 15–20 mm. long, heterogone; sepals ovate, obtuse, with two more or less confluent orange callosities on the outer side at the tip; petals thrice as long as the calyx, undulately obtuse or truncate, rose-purple or sometimes white; capsule round-ovoid, about 5 mm. long, its cells about 3-seeded, glabrous; seeds

[1] These callosities, or so-called glands, are common to many species of this section of *Oxalis*. In *O. Martiana*, *bipartita*, etc., an intramarginal series of small callosities of the same nature occurs around the lower surface of the leaflets.

compressed ovoid, irregularly rugose-tuberculate, 1.5 mm. long.—Woods, Vermont to Florida, west to the Rocky Mountains and Texas; the western form common in dry open groves.—Pl. 11, fig. 10.

10. O. LATIFOLIA, HBK., Nov. Gen., v, 237, Pl. 467, VAR. Acaulescent, a span or more high, from a small scaly bulb which bears numerous subterranean bulbiferous shoots two or three inches long, subglabrous; leaflets 3, without apical callosities, very broadly obcordate-deltoid with oblong divergent lobes, more or less ciliate; flowers about as in the last; alternate filaments with lateral auricles; capsule (immature) linear-oblong, 10 mm. long, its cells about 5-seeded; seeds flattened, ovate, acute above, transversely rugose, with about 4 longitudinal grooves on each side, .75 × 1.2 mm.—Arizona (*Pringle*, 1881, no. 300, *Lemmon*, 2654), from Mexico and South America. Leaves smoother, less conspicuously veined and more deeply parted than in the figure cited, and the stamens different, but agreeing well with various Mexican specimens referred to *O. latifolia* (*e. g. Botteri*, 1122).—Pl. 11, fig. 12.

11. O. VESPERTILIONIS, Torr. and Gray, Fl. N. Amer., I, 679. *O. Drummondii*, Gray, Pl. Wright., II, 25; Torrey, Bot. Mex. Bound., 41; Watson, Index, I, 153. Hemsley, Biol. Centr. Amer., I, 163. Acaulescent from a scaly bulb, glabrous; leaves few, about a span high, leaflets 3, open V-shaped, more or less conspicuously calloused in the sinus, the linear blunt lobes 10–25 mm. long, usually 5 mm. or less wide; scape nearly twice as long as the leaves, mostly solitary, umbellately about 6-flowered; pedicels at length an inch long; bracts acutish; sepals with 4–6 narrow callosities, flowers otherwise about as in *O. violacea*, heterogone; capsule ovoid-oblong, somewhat pubescent, 10 mm. long, its cells about 4-seeded; seeds as in *O. decaphylla*.—Texas (*Lindheimer*, 175, 341, 457, *Wright*, 716, *Drummond*, 8).—Pl. 11, fig. 13.

12. O. DIVERGENS, Benth., Pl. Hartweg., 9. *O. vespertilionis*, Gray, Pl. Fendler., 27. *O. violacea*, Gray, Pl. Wright., I, 27, II, 25. An inch and a half to a span high, glabrous (or somewhat hairy ?), with the flowers and habit of *O. violacea*. Leaflets 3–5, mostly 4, deeply obcordate or cuneate-bilobed, without an apical callosity, 10–20 mm. long and about as broad, the sinus extending to the middle, lobes divergent, mostly narrowed upwards; fruit ?—New Mexico (*Fendler*, 91, *Wright*, 908) and Arizona (*Rusby*, September, 1883), from Mexico.—Pl. 11, fig. 11. Similar to *O. tetraphylla*, Cav., but smaller. A large specimen distributed by the Department of Agriculture without locality or date may possibly be the latter.

13. O. DECAPHYLLA, HBK., N. Gen., Sp., v, 238, Pl. 468. Acaulescent from a more or less hairy bulb which produces short-stalked bulblets, glabrous; leaves several, about a span high; leaflets 5–10, linear-obcordate–Y-shaped, 20–35 mm. long, the sometimes sparingly ciliate lobes 3–5 mm. wide, midrib ending abruptly, not callous-tipped; scapes mostly twice as long as the leaves, umbellately about 10-flowered; flowers heterogone about as in *O. violacea*, but the sepals mostly with 4–6 callosities; capsule ovoid-oblong, 8 mm. long, its cells about 4-seeded; seeds pale brown, compressed, round-ovoid, longitudinally 8–10-creased and transversely wrinkled, .7 × .9 mm.—Arizona (*Greene*, 1880, no. 211, *Pringle*, 1881, 301, *Lemmon*, 2653) and New Mexico (*Wright*, 909), extending into Mexico. In some Mexican specimens, apparently to be referred here, the scape

and petioles are puberulent or loosely villous, and the leaflets are occasionally somewhat hairy. It should be noted that our flowers of this species and *O. latifolia* are much larger than those figured by Kunth.—Pl. 11, fig. 14.

A comparative biological study of the species of this genus, with abundant material, would be of unusual interest. Those like *O. corniculata*, var. *stricta*, which produce leafy stems, but spread by subterranean shoots, show how the caulescent type may be connected with the acaulescent, as represented by the *acetosella* group, which produce their leaves and flowers from the apex of a slender rhizome. These forest-inhabiting species, with persistent stipular-dilated leaf-bases aggregated about the terminus of each year's growth, while the scales are remote elsewhere, pave the way for the *violacea* group, many of which are prairie or desert species. In some tropical American species of this group, the so-called stipe, rising to the surface of the ground, is sparingly scaly, suggesting the rhizome of *O. acetosella*, while the subterranean part of *O. enneaphylla* might be called with almost equal propriety a stout scaly interrupted rhizome, or a closely aggregated series of bulbs. But, in the majority of these species, vegetative propagation is effected by bulbiferous shoots, the bases of which disappear after a time, while the inner leaf-bases persist at the apex as fleshy reservoirs of food, and the outer scales, at length dry and sclerotic, usually villous-ciliate or quite hairy, sparingly glandular and charged with resin-cells, serve as protecting organs. The earliest vegetative energy of these bulbiferous plants in early spring goes to the expansion of foliage and flowers, but is soon diverted to the formation of a fleshy tap root, rich in water which is drawn upon as the season of abundant moisture is succeeded by the drought of summer, so that plants that grow in exposed districts are able to mature their fruit, while those in the woods frequently bloom through the late summer and autumn, long after their leaves have disappeared; finally the remaining store of water is applied to the ripening of the bulb.

Hildebrand,[1] who has considered this subject at length, notes, apparently with reason, that African species, which are exposed to greater heat during the dormant season than those of America, uniformly produce bulbs that are protected by a thicker scaly coating, while, by the greater length of their subterranean shoots, they are carried deeper into the earth. The enlargement of the apices of these shoots with an accompanying reduction of their scales, or of the apices of slender rhizomes like those of *O. corniculata*, var. *stricta*, results in tubers such as characterize *O. crassicaulis*[2] and other species, several of which bear large and edible tubers.

While these cases may serve to illustrate the modification of the simple caulescent type in one direction, *O. Wrightii* departs from the *corniculata* type in developing a stout subterranean caudex, from the summit of which the leafy branches spring, and this form is much intensified in a group of acaulescent South American species with thick

[1] Schutzeinrichtungen bei den Oxaliszwiebeln (Ber. deutsch. bot. Gesellsch., II, 108); Lebensverhältnisse der Oxalisarten, Jena, 1884,—abstract in Bot. Centralbl., XIX, 225.

[2] Zuccarini: Nachtrag Monogr. Amer. Oxalisarten, Pl. 2.

trunks, of which *O. articulata*[1] is a representative. On the other hand, there is no doubt that the latter approach the bulbiferous type, through the *enneaphylla* form already described.

Commonly the leaflets are digitately clustered at the end of an elongated petiole; but the pinnate type, represented among our species by *O. Berlandieri*, is not uncommon in the tropical American species, and in the section *Biophytum* the elongated leaves consist of a large number of crowded leaflets. On the other hand the suppression of all but the terminal leaflet results in the unifoliolate leaf of *O. dichondraefolia* and a few species that do not occur in our territory; and in *O. rusciformis* (sometimes quoted and figured as *O. frutescens*), the reduction and final abortion of the leaflets, accompanied by an unusual dilatation of the petioles, results in as perfect phyllodia as those of *Acacia*,—but these stand with their edges tangential to the stem, not radial as in the latter genus. A transition to this type is afforded by a considerable series of species in which the petioles are more or less dilated and efficient in assimilation. On the other hand, Hildebrand[2] has pointed out that the leaves of seedlings of *O. Lasiandra* are at first trifoliolate, though the later leaves consist of 7–9 leaflets.

The leaves of *Oxalideae* have long been known to possess the power of movement in a marked degree. The change of position of the leaflets at night, so that they are then exposed to a minimum cooling by radiation — the so-called sleep of the leaves — is a familiar example. Under the influence of light and warmth, this position is exchanged in the daytime for one in which they have the best exposure for assimilation; but a sudden and intense illumination causes the leaflets to close again more or less, and continued exposure to either light or darkness for a period of days breaks the readiness of their response to either, while it has been shown that if so fastened that they cannot close at night, they soon become feeble or die.

In *Averrhoa*, the leaflets are usually in evident motion, from an intensification of their circumnutation, — a movement which has been carefully studied by Mr. Darwin in many plants. In this respect they resemble the small lateral leaflets of *Desmodium gyrans*, the common "telegraph plant" of greenhouses. It is also known that the leaves of *Biophytum*, to a certain extent those of *Oxalis acetosella*, and in a still less degree of other species, are influenced by shocks, which cause the leaflets to assume the nocturnal position with more or less rapidity, as in *Mimosa*, *Robinia*, etc. The seat of these different movements is in the pulvini near the base of the general petiole and of the short stalks of the leaflets, and in the midribs of the latter.

The flowers of most species are solitary or umbellately clustered; but in the former case the peduncle is 2-bracted some distance below the flower, and the umbels are likewise subtended by two or more bracts. In specimens of *O. violacea*[3] some of the branches of the umbel have been observed to branch, and this, with the constant presence of the bracts referred to, indicates that the inflorescence in these cases is in reality a reduced cyme. A typical dichotomous cyme is, in fact, regularly developed in luxuriant specimens of *O. corniculata*, var. *stricta*[4]. In *O. Brasiliensis*, bulblets have been observed,

[1] Bot. Magazine, CX, Pl. 6748.

[2] Bot. Zeitung, 1887, 3.

[3] Zuccarini: Monogr. Oxalid., 19; Jacquin: Hort. Vindob. 84, Pl. 180.

[4] On this subject see Zuccarini: Nachtrag Monogr. Amer. Oxalisarten, 190; Wydler: Pringsheim's Jahrb. wiss. Bot. IX; Eichler: Blüthendiagramme, II, 301, etc.

replacing flowers, and Plukenet[1] states that the flowers of our *O. violacea* are sometimes succeeded by bulblets,—an occurrence that cannot be common in the wild plant.

The flowers are typically open funnel-shaped, expanding in sunshine, the degree of warmth playing a very important part in this process, at least in some species[2]. The stamens are in two sets of unequal length, as in *Geranium*, etc., while the styles appear to be typically about equal to the longer set. But in the majority of species the flowers of different individuals are quite dissimilar in this respect, so that these species are what Hildebrand[3] and Darwin[4] have called heterostyled, or Gray[5], heterogone. In *Oxalis* the heterogony is typically trimorphism, three forms of flowers existing in about equal numbers on different plants of a given species, the pistils of one being shorter than the shortest stamens (short-styled), those of the second being intermediate between the two sets (mid-styled), while those of the third are longer than either set of stamens (long-styled). Connected with these differences in the length of the pistil are differences in the stamens, so that the two sets of either form of flower correspond in length respectively with the pistils of the two other forms. Hildebrand, who examined the specimens of *Oxalis* in several large herbaria, has recorded his observations on this point in detail[6]. But while the appearance in a majority of cases was that of trimorphism, only one or two forms of flowers were found in many of the species examined. In most instances, however, these correspond to one of the three forms that I have characterized. The same may be said of the many figures of Jacquin[7] and others who have illustrated this genus. It was also shown by Hildebrand[8] that in some trimorphic species submitted to experiment, the greatest fruitfulness resulted only from the fertilization of a pistil by the pollen from stamens of its own length,— a rule that has been found to apply generally to heterogone plants[9]; and Hildebrand has recently again remarked on the frequent self-sterility of a single form[10]. The pollen and stigmas of such trimorphic species as have been examined in this respect, also show the differentiation usual in trimorphic plants, the pollen grains of the long stamens being largest, those of the short stamens, smallest, and those of the mid-length, intermediate in size; while the stigmatic papillae of the long-styled flowers are longest, those of the short-styled, shortest, and those of the mid-styled, of intermediate length.

In the examination of herbarium or greenhouse material of trimorphic species, the number of specimens being limited, it may readily happen that only one or two of the forms are found, when a search in the field among hundreds of individuals would reveal all in approximately equal numbers. But even under these conditions, one or more of the forms may not be found in localities where an introduced species has multiplied non-sexually[11], or where but two forms have been introduced; for these, propagated sexually, but without the intervention of the other forms, may possibly reproduce only themselves[12]. Hence the presumable trimorphism of such species as were known to have one or two of the forms of flowers usual in such cases has not been generally disputed.

Some years since, having access for the first time to numerous wild plants of a sup-

[1] Almagestum Bot. 1, Pl. 102, fig. 4.
[2] Cf. Pfeffer: Physiol. Unters. 1873.
[3] Monatsber. Berlin. Akad. 1866, 369.
[4] Different Forms of Flowers, various places.
[5] Amer. Journ. Sci. and Arts, 3 Ser., XIII, 82.
[6] Monatsber. Berlin. Akad., 1866, 351.
[7] Oxalis Monographia, 1794.
[8] Bot. Zeitung, 1871, 415, 431.
[9] Darwin: Different Forms of Flowers, etc., Chapter 5.
[10] Hildebrand: Bot. Zeit. 1887, nos. 1–3.
[11] Darwin: Different Forms of Flowers, 182.
[12] Hildebrand: Monatsber. Berl. Akad., 1866, 373; Bot. Zeit., 1887, 5 ;Darwin: Different Forms of Flowers, 268.

posed trimorphic species (*O. violacea*), and observing only long- and short-styled plants, I made measurements of the flowers of many plants, but found only these two forms, although the plant is very abundant and a native species. I have since examined a great many more plants about Madison, Wisconsin, in the vicinity of St. Louis, Mo., and from central Illinois, without finding a single mid-styled flower; and my correspondents who have paid attention to the subject have had the same experience. Numerous herbarium specimens, representing nearly the entire range of the species, are also all long- or short-styled. From a careful consideration of these facts, I have been convinced that this species has become dimorphic from the suppression in some manner of the mid-styled form, for it cannot be doubted that it is descended from originally trimorphic parents, since the stamens are still in two remote sets, not as yet combined in a single set, though in flowers of both sorts they appear to be somewhat closer together than they should be in a trimorphic species. Mr. B. M. Vaughan, who studied *O. violacea* in my laboratory some years since, thought that he detected an abortion of the pollen of the mid-stamens in both long- and short-styled flowers, indicating a loss of function that might be held as indicative of their ultimate disappearance. How far this may be true I do not know. Mr. Darwin, to whom some of these facts were communicated shortly before his death, also thought that this might be a trimorphic species becoming or become dimorphic[1]. I may add that our other species of the *violacea* group are found only under these two forms in herbaria, so far as I have examined them; but Hildebrand has cultivated the mid-styled form of *O. vespertilionis*[2].

Our yellow-flowered caulescent species of the *corniculata* group are more puzzling than those which have just been considered. In the typical smaller-flowered form of *O. corniculata* and its variety *stricta*, the styles are a little shorter than, or about equal to, the longer stamens, and the flowers are unquestionably homogone[3]. But in the common villous St. Louis plant, which is regarded as a form of var. *stricta*, the flowers are larger and the pistil appears to have increased in length correspondingly with the petals, as may be seen from the following measurements, from the base of the flower (Table I). These flowers might be taken for the long-styled form of a trimorphic species; but the pollen-grains from both sets of stamens are essentially of the same size, so that this theory is untenable[4], and both *corniculata* and this variety are to be regarded as merely variable in the relative length of stamens and pistil[5].

There are also numerous stipulate specimens which could be referred to *O. corniculata* in the broad sense in which that species is understood, if it were not that they are still larger-flowered and may be trimorphic. I append some measurements of the stamens

[1] As I stated in the American Naturalist, in 1882, Hildebrand (Monatsber. Berlin. Akad., 1866, 357,—and recently in Bot. Zeitung, 1887, 22) reports one mid-styled specimen of *O. violacea*, without locality, in the herbarium of Alexander Braun; and a figure of a mid-styled flower of what is called *O. violacea* is given by Payer (Organogénie, Pl. 11, fig. 19,—copied in Luerssen's Handb. Syst. Bot., II, 168). I also find several mid-styled specimens under this name, from about Buenos Ayres, in the Gray herbarium, but they are not our North American plant.

[2] Lebensverhältnisse der Oxalisarten, 36.

[3] See Hildebrand: Monatsber. Berl. Akad., 1866, 368; Bot. Zeit., 1887, 37.

[4] Hildebrand (Monatsber. Berl. Akad., 1866, 368–9) found one long-styled specimen of *stricta* collected by Treviso (but without indication of locality), and one from Missouri, while a specimen from Kentucky is said to be short-styled.

[5] See Darwin's Different Forms of Flowers, 181.

TABLE I.—Large-flowered O. CORNICULATA. var. STRICTA.

Length of Stamens.		Stamens.	Pistil.	Corolla.
From one plant.	3 mm.	4 mm.	7 mm.	10 mm.
	3	4	7	10
	3	5	7	9
	3	4	6	9
	3	5	6	9
	3	4	5	6
	2	3	5	8
	3	4	7	8
From one plant.	3	5	8	9
	3	5	6	8
	3	4	5	6
	3	4	5	8
Average.	3 mm.	4.3 mm.	6.2 mm.	

TABLE II. O. CORNICULATA, var. (?) MACRANTHA.

A. Long-styled.

Locality.	Length of stamens.	Stamens.	Pistil.
Florida.	4 mm.	5 mm.	7 mm.
"	5	6	6.5
New York.	4	5	7
California.	4	5.5	6

B. Mid-styled.

	Stamens.	Pistil.	Stamens.
New York.	4 mm.	5 mm.	6 mm.
California.	5	7	9
"	6	7	8
"	4.5	5.5	6

C. Short-styled.

	Pistil.	Stamens.	Stamens.
Florida.	5 mm.	6 mm.	7 mm.

D. Doubtful.

	Stamens.	Stamens.	Pistil.
Florida.	5 mm.	6 mm.	6 mm.
"	5	6	6

and pistils (Table II), but have not had an opportunity to measure the pollen of the different sets of stamens. Some of the specimens come very near *O. pilosa*, Nutt., as represented by a flowerless specimen of Nuttall in the Torrey herbarium. It will be seen that the last two (and others have been observed) have the styles equal to the longer stamens, as in typical *corniculata*, although the flowers are very much larger. Botanists who are able to study this large-flowered form in the field should make the measurements on a large number of specimens, necessary to determine whether it is heterogone or not.

While the heterogony of this form is at best only presumable, we have two truly trimorphic species of this section, as may be seen from Tables III–VI.

As these species are all very closely related, they appear to illustrate the manner in which an originally homogone species, variable in the relative length of stamens and pistils in some of its forms, may give rise to others which are trimorphic.

The specimens of *O. acetosella* and its variety *Oregana*, and of *O. trilliifolia*, that I have examined, agree in having the two sets of stamens very unequal in length, while the pistils mostly considerably surpass the longer set[1]. The appearance is, therefore,

[1] *Cf.* Darwin: Different Forms of Flowers, 182; and Hildebrand: Monatsber. Berl. Akad., 1866, 366; Bot., Zeit., 1887, 36.

TABLE III. O. SUKSDORFII.

A. Mid-styled.			
Length of stamens.	Pistil.	Stamens.	Corolla.
5 mm.	6 mm.	8 mm.	16 mm.
B. Short-styled.			
Pistil.	Stamens.	Stamens.	
5 mm.	6 mm.	8 mm.	16 mm.
6	7	10	18
5	7	9	13

TABLE IV. POLLEN OF O. SUKSDORFII.[1]

A. Mid-styled flower.		*B. Short-styled flower.*	
Long Stamens.	Short Stamens.	Long Stamens.	Mid Stamens.
50 μ	33 μ	50 μ	43 μ
43	36	50	43
? 40	36	47	? 50
43	36	50	40
43	33	50	36
47	33	53	47
47	33	47	40
47	33	47	40
47	36	47	36
47	33	53	36
43	33	47	47
47	36	47	43
47	34	47	47
43	36	50	43
47	33	50	40
Average 45.4 μ	34.2 μ	49 μ	42 μ

as if these might be the persistent long-styled form of originally trimorphic ancestors. But as the pollen of the two sets of stamens does not show the differentiation that would be expected in that case, it is more probable that they are to be compared with the still undifferentiated and homogone *O. corniculata.*

In all of our species the flowers are adapted to pollination by bees, which are attracted by their conspicuous color, and usually directed by veins of a deeper shade to a more or less abundant supply of nectar secreted by a series of small glands at the bases of alternate stamens, on the outside. This is generally protected from rain and dew by the hairiness of the longer stamens or styles, as well as by the closing of the flowers at night and in cloudy weather. *O. corniculata* and *O. acetosella*, the only cosmopolitan species, apparently owe their extensive distribution to the facility with which they are self-fertilized. The small flowers of the former are freely self-fertile, although they are visited and intercrossed by small bees in sunny weather, presumably with benefit to the species; and the latter produces reduced but extremely fruitful cleistogamous flowers on pedicels that are concealed at the base of the plant[2].

While the North American species deviate very little from the open funnel shape that appears to be typical of the genus, this is not true of all species. The corolla of *O. macrostylis*[3], for example, a South American species, is lengthened into a slender tube 2 × 15–25 mm., a modification which clearly adapts the flowers to pollination by lepidoptera. (Note 10.)

Oxalis is a genus with explosive fruit. (Note 11.) At maturity the carpels dehisce along

[1] In both tables of pollen measurements, the shorter diameter of freshly swollen grains from herbarium specimens is given.

[2] According to Hildebrand (Lebensverhältnisse, 22) *O. Oregana*, in cultivation, produces only open flowers through the entire season.

[3] Jacquin: Oxalis Monogr., Pls. 9–12. On this species, see further Walpers, Repertorium, 1, 477; and Hildebrand: Monatsber. Berl. Akad., 1866, 361–2.

the dorsal suture[1], and, at the slightest touch, their seeds are expelled in rapid succession to a distance of several feet. In gathering *O. corniculata*, I have been surprised at the sudden pattering of a dozen seeds against my face and clothing, while the capsule was apparently still closed, and it was only on closely examining it that I could convince myself that it was really dehiscent and empty, the valves remaining close together. The mechanism by which the seeds are expelled is quite unlike that of any other plant with which I am acquainted. In the ripening of the seed the inner integument becomes firm and hard, while the outer develops into a thick fleshy loose arilloid envelope, that ultimately splits longitudinally on the side opposite the raphe, and, pressing upon the somewhat flattened sides of the seed, forces it out, much as a boy would snap an orange seed from between his thumb and forefinger.

TABLE V. O. RECURVA.

A. Long-styled.

Length of stamens.	Stamens.	Pistil.
5 mm.	6 mm.	9 mm.
6	8	10
4	6	8
5	7	9

B. Mid-styled.

Stamens.	Pistil.	Stamens.
4 mm.	6 mm.	8 mm.

C. Short-styled.

Pistil.	Stamens.	Stamens.
4.5 mm.	6 mm.	8 mm.
4	6	8

TABLE VI. POLLEN OF O. RECURVA.

A. Long-styled flower.		*B. Short-styled flower.*	
Mid stamens.	Short stamens.	Long stamens.	Mid stamens.
33 μ	27 μ	36 μ	33 μ
30	27	36	33
27	30	33	30
30	23	33	33
30	23	36	36
30	27	33	30
27	27	33	33
27	23	33	33
27	23	33	30
30	23	36	30
27	30	33	33
30	30	33	33
27	27	33	33
27	27	36	33
27	23	36	30
27	23	36	33
30	20	33	33
27	27	36	33
27	23	33	33
27	30	33	33
27	27	33	33
27	27	33	33
Average 28.2 μ	25.7 μ	34.1 μ	32.4 μ

BALSAMINEAE.

Flowers irregular, 5-merous, usually unsymmetrical from the suppression of 2 sepals, homogone; sepals and petals imbricate, deciduous; stamens 5, glands wanting; carpels alternate with the sepals, several-ovuled.— *Balsaminaceae* of continental writers; two genera, one containing only a single species.

[1] In § *Biophytum* they separate stellately and open on the inner suture.

IMPATIENS, L. Gen. no. 1008; Benth. and Hook., Gen., I, 277.

Annual herbs with succulent translucent stems, and thin alternate petioled simple leaves, without stipules; flowers several, on loosely branched bracteate axillary peduncles; sepals 3, the posterior petaloid, saccate, and mostly slender-spurred; petals 5, the lateral ones on each side united; stamens united somewhat by their appendaged filaments, and with more or less connate anthers; style almost none; ovary not deeply lobed, its valves breaking elastically from their septa and coiling; seed oblong, with four longitudinal ridges, otherwise nearly smooth, exalbuminous, the embryo straight with nearly plane cotyledons.— About 135 species, 20 in Africa; most of the others in tropical Asia.

1. I. FULVA, Nutt. Gen. I, 146. *I. biflora*, Walt. *I. nolitangere*, β, Michx. *I. maculata*, Muhl. Two to four feet high, branched, glabrous, somewhat orange or purple-tinted; leaves usually 2–3 in. long, a little glaucous below, elliptical-ovate, rather obtuse, coarsely crenate-serrate, the short teeth mucronate or the lower subulate, base subcordate or mostly acute; lower petioles about equalling the blade, the upper shorter; peduncles equal to the leaves or the upper longer; pedicels 2–4, each with a single linear bract about the middle; flowers orange-yellow mottled with red-brown; saccate sepal longer than broad, rather abruptly contracted to a slender spur which is half as long as the sac or more, notched at the end, and usually closely incurved; cleistogene flowers produced in abundance, the coherent nearly regular perianth carried up on the maturing ovary; capsule oblong, 1–4-seeded; seeds somewhat compressed, 3 × 5 mm.—Wet places, Canada to Florida, west to Oregon and Alaska (*fide Meehan*); introduced into England. Pale, spotless flowers sometimes occur; and others destitute of a spur have been collected from Massachusetts (*Robbins*) to the Columbia Valley (*Lyall*). Very similar to the European *I. nolitangere*, which has a more cornucopioid sac with its spur not toothed at the end, and larger lateral petals.

2. I. PALLIDA, Nutt. *l. c.* *I. nolitangere*, Michx. *I. aurea*, Muhl. Larger in every way, as much as 5–6 feet high, and paler; leaves sometimes 10 × 17 mm., usually 5 × 9 or less; flowers pale yellow, less prominently mottled; hooded sepal as broad as long, the notched spur not so closely incurved and less than one-third its length; bracts ovate, acute; otherwise like the last.—Wet places, Canada to Georgia, west to Saskatchewan and Oregon, usually less abundant than the preceding. A pink-flowered form is found in New York (*Dudley, Cayuga Flora*, 19).—Pl. 12, fig. 15.

The lower teeth of the leaves of some species of *Impatiens* are more or less nectariferous at the apex; or, as in the garden balsam (*I. balsamina*), the petiole also bears several such glands, which are homologous with the serrations of the blade. According to Delpino, these are contrivances by which a body-guard of ants is kept on the plant, for its defence against caterpillars and other enemies.

The flowers of *I. pallida* and *I. fulva*, like those of the related European *I. nolitangere*, secrete nectar in a spur formed from the prolonged posterior sepal, and advertised by the bright coloring of this sepal and the petals. They are protandrous, and evidently adapted to pollination by rather long-tongued humble-bees, which find an alighting place

on the lower petal and the floor of the saccate sepal, and touch anthers or stigma with their backs while feeding on the nectar. Bennett, the only one who has carefully studied the flowers from this standpoint, has shown that the appendages on the inner side of the filaments form a hood which, in conjunction with the pendent position of the flowers, effectually prevents self-pollination. The nectar spurs are frequently perforated by humble-bees, and hive-bees subsequently make use of these perforations to abstract nectar. Delpino has shown that some exotic species are apparently pollinated by lepidoptera,—the long-spurred *I. Sultana*, which is now extensively grown as a greenhouse or border plant, is evidently of this class, and according to Baillon, *I. Humblotiana*, of Madagascar, is ornithophilous. It should be noted also that humming-birds are not infrequent visitors to our own *I. fulva*. Both of our species bear regular cleistogamous flowers on the axillary peduncles, and the greater part of their fruit results from the fertilization of these reduced flowers, which are very abundant.

The ripening capsules are in a state of tension which finally results in the outer part of the valves breaking away below from their septa, which remain, with the seeds, attached to the persistent axile column. The liberated valves then rapidly coil up, stripping or shaking off the seeds as they do so, and often throwing them to a considerable distance from the plant. (Note 12.)

The tribe *Pelargonieae*, which is not represented in our district, but is well known in the cultivated "geraniums" (*Pelargonium*) and nasturtion (*Tropaeolum*), possesses some interesting peculiarities connected with pollination, which can only be indicated in the briefest outline here. The flowers are protandrous, with one sepal produced as a long spur that is adnate to the pedicel in the former, and free in the latter genus. The epidermis, lining the narrow cavity of this spur, is provided below with short, unicellular hairs, the walls of which are thickened in a peculiar manner at the apex, the interior of the swollen tip finally undergoing a mucous degeneration connected with the secretion of nectar. Occasionally the cavity of the spur is double in *Pelargonium*, and in abnormal cultivated forms it sometimes disappears; the well-marked veining of the upper petals, which serves as a nectar-mark, then disappearing also, as Mr. Darwin has shown.

In *Pelargonium zonale*, etc., the flowers are well adapted to pollination by butterflies. Owing to their lateral position, their petals are unequal, as has been shown to be the case in *Erodium*. This irregularity is somewhat intensified in the common "rose-geranium" (*P. graveolens*), and very much so in *P. tetragonum*, etc., the flowers of which Delpino has not inaptly compared with the papilionaceous type of Leguminosae. Not a few species of this genus are nearly scentless during the day, but extremely fragrant at night, and in this and other peculiarities indicate adaptation to cross-fertilization by nocturnal moths. *Tropaeolum*, with numerous species, presents a series ranging from such as are bee-pollinated to others which are as clearly ornithophilous. (Note 13.)

REFERENCES CONCERNING GERANIACEAE.

Jännicke: Beitr. z. vergl. Anatomie der Geraniaceae (Abhandl. Senckenb. naturh. Gesellsch., XIV, Heft 3; Bot. Centralbl., XXXI, 36).

1. On the general anatomy of Geranium see Irmisch: Bot. Zeitung, 1874, 545, etc. Modified stomata (water-pores) of *G. Robertianum* are discussed by Reinke; Jahrb. wiss. Bot., X. The appearance of adventive buds on the roots, in some cases, is noted by Warming: Bot. Tidsskrift, II; Just, V, 374. Weiss: Pflanzenhaare, 1867, and Anatomie der Pflanzen, 1878, I; Just, VI[1], 33-4, describes the characteristic forms of trichomes.

2. On the inflorescence of *Geranieae* see Wydler; Jahrb. wiss. Bot., XI, Heft 3; Just, V, 362: Eichler; Blüthendiagramme, II, etc.

3. On the morphology of the flowers of *Geranieae* see Frank: Jahrb. wiss. Bot., X; Eichler: Blüthendiagramme, II; Baillon: Hist. des Plantes, V, etc., where other references are to be found. Instructive observations on teratological flowers of *G. Robertianum* are given by Christ, in the Botanische Zeitung for 1887, 6, pl. 1, as this is being written.

On the pollination of *Geranium* see Axell: Anordningarna Fanerog. Befr. 106 (several species); Bennett: Journ. Bot., 1872, 25 (*G. Robertianum* self-fertile in late autumn); Bonnier: Ann. Sc. nat., 6 sér., VIII, 146, pl. 8, f. 118–132 (histology of nectar-glands); Bonnier and Flahault: Ann. Sc. nat. 6 sér., VII, 111 (brighter color of *G. Robertianum* at high elevations); Buckley: Fairy Land of Science, 221 (*G. sylvaticum*); Darwin: Cross- and Self-fertilization, 420 (secretion of nectar after fall of petals in *G. phaeum*); Delpino: Ulteriori Osservazioni, II[2] (nectary, 97); pollination, 105; early falling of anthers, 163; visits of *Rhyngia rostrata* to *G. pyrenaicum*, 317); Fecond. delle Piante Antocarpee, 30; Dodel-Port: Illustr. Pflanzenleben, Lieferung 7; Errera: Compt. rend. Soc. roy. Bot. Belg. XVIII, 15, 42 (*G. phaeum*); Errera and Gevaert: *l. c.* XVII, 132 (*G. phaeum*); Goodale: Wild Flowers of America, 18; Heckel: Comptes rend., 1878, ? (movements of stamens); Henslow: Trans. Linn. Soc. n. s., I, 357–8 (self-fertilization); Hildebrand: Bot. Zeit., 1865 (experiments on *G. pratense*); Geschlechtervertheilung, 17, f. 3 (*G. pratense*, protandrous); Irmisch: Bot. Zeit., 1874, 565 (normally reduced flowers of *G. sanguineum*); Kerner: Flowers and their unbidden Guests, 112 (*G. Robertianum*); Kirby and Spence: Entomology, 462 (Bees, *Epeolus variegatus*, sleep suspended by their mandibles from the beak of *G. phaeum*, according to Linnaeus); Knaggs: Lepidopterist's Guide, 88 (lepidoptera at flowers); Lubbock: British Wild Flowers (*G. sylvaticum*, 2; *G. pratense*, 37; comparison of large- and small-flowered species, 43, 72); Scientific Lectures, 14 (résumé); Mignault: Nat. Canadien, XII, 247; Müller: Nature (visitors of *G. sylvaticum* and *G. pratense*, XI, 33; gynodioicism of *G. sylvaticum*, XVIII, 519; Weitere Beobachtungen, II, 217–8 (visitors); Befruchtung der Blumen, 160 (comparative study of the German species); Alpenblumen,—(study of Alpine species); Fertilization of Flowers, 149 (general review of European species); Ricca: Atti Soc. Ital. Sci. Nat, XIII, 256 (*G. phaeum*); *l. c.* XIV, 252 (*G. sanguineum*); Roth: Beyträge (1783), II, 70 (nectary); Soyer-Willemet: Le Nectaire, 36 (nectary); Sprengel: Neu entdeckte Geheimniss der Natur (1793) (*G. sylvaticum*, I, 338; *G. palustre*, 335; *G. Robertianum*, 337; *G. sanguineum*, *pratense*, *reflexum* and *molle*, 338); Thomson: Trans. Bot. Soc. Edinburgh, XIV, 102 (*G. microphyllum* and *molle* in New Zealand).

Grieve (Gard. Chron. n. s., V, 699, VI, 49) gives an account of a supposed hybrid of *Pelargonium zonale* and *G. pratense*. On the histology of the embryo see Flahault: Ann. Sc. nat., 6 sér., VI, 112; Gérard: Ann. Sc. nat., 6 sér., XI, 330.

4. On the mode of dissemination of *Geranium* see Bischoff: Lehrb. Bot., II[1], 470; Hildebrand: Verbreitungsmittel der Pflanzen, 37; Jahrb. wiss. Bot., IX, 269, pl. 25(= 3), f. 38. Lubbock: Pop. Sci. Monthly, XIX, 164; Flowers, Fruits and Leaves, 57 (from Fortnightly Review); Steinbrinck: Bot. Zeit., 1878, 580; Zimmermann: Jahrb. wiss. Bot., XII, 568, pl. 36. Also Gibson: Harper's Mag., Oct., 1885, 687; Olvers: Bot. Centrabl., XXI, 318 (Just, 1884[1], 685).

On the seed-structure, see Marloth: Engler's Bot. Jahrb., IV, 237, pl. 5, f. 9–10; Strandmark: Bidr. till Kännedomen om Fröskalet's Byggnad. Thesis, Lund., 1874, 27, f. 15. The development of the embryo is discussed by Hegelmaier: Vergl. Unters. Entw. dikot. Keime, 1878; and Hofmeister: Embryobild. Phanerog., 92; and an account of the chlorophyll it contains is given by Flahault: Bull. Soc. Bot. de France, 1879, 250–1; Ann. Sci. nat., 6 sér., IX, 174.

5. For the leaf-position of *Erodium* under varying circumstances, *cf.* Kraus: Flora, XXXVII, 71. Goeppert has observed that the leaves or *E. cicutarium*, like those of a number of other plants, become red during the winter months, when covered by snow, resuming their green color in spring.—Sitzber. Schles. Gesellsch. Naturk., Jan. 20, 1876.

6. On the pollination of *Erodium* see Bonnier and Flahault: Ann. Sci. nat., 6 sér., VII, 105 (flowers more brightly colored in high latitudes); Delpino: Ulteriori Osservazioni, II[2], 97 (nectary); Henslow: Trans. Linn. Soc. Bot., 2 ser., I, 358 (*E. cicutarium*, self-fertile); Jordan: Flora, LXIX (1866), 251-2, pl. 5, f. 17 (*E. cicutarium*); Ludwig: Kosmos, VIII, 357 (general discussion of pollination); Irmischia. II, 5 (*E. cicutarium* and var. *pimpinellaefolium*); Bot. Centralblatt, VIII, 87 (*E. macradenum* and *E. cicutarium*); Müller: Kosmos, IV, —; Wechselbeziehungen, 94-5 (*E. cicutarium*); Weitere Beobachtungen, 218 (*E. cicutarium*); Befruchtung der Blumen, 166 (*E. cicutarium*); Fertilization of Flowers, 83 (*E. cicutarium*); Soyer-Willemet: Le Nectaire, 37 (nectar-glands); Sprengel: Entd. Geheimniss der Natur (*E. cicutarium*, 338; *E. moschatum*, 340; Weihe: De Nectariis, 21, 39 (nectar-glands).

7. On the structure, dissemination and self-planting of *Erodium* fruits see Ascherson: Jahrb. Berl. Gart., I, 321, pl. 6; August (see Hanstein); Bischoff: Lehrb Bot., II[1], 470; Cooke: Freaks and Marvels of Plant Life, 281; F. Darwin: Trans. Linn. Soc., 2 ser., I, 155; DeCandolle: Physiol. Vég., II,—; Delpino: Pensieri, 11; Goodale: Common Plants, 57; Gray: Amer. Journ. Sci. and Arts, 3 ser., XI, 158; (August and) Hanstein: Sitzber. naturh. Ver. Rheinl. u. Westph., 1868, 95; Bot. Zeitung, 1869, 530; Hildebrand: Jahrb. wiss. Bot., IX, 265, pl. 25 (referred to as pl. 3), f. 33–7; James: Bot. Gazette, IV, 209; Lubbock: Pop. Sci. Monthly, XIX, 364; Flowers, Fruits and Leaves, 88 (from Fortnightly Review); Macloskie: Nature, XXV, 174; Mallet: Mag. Nat. Hist., IX, 22, 10 figures: Meschajew: Proc. Assoc. Naturalists and Physicians, St. Petersburg, 1880, 19–20 (Just, VIII[1], 243); Nobbe: Handb. Samenkunde, 486, f. 323; G. Roux: Ann. Soc. Bot. de Lyon, 1873, 25; Compt. Rend. Assoc. française, II, 582; Sachs: Text Book, 841; Stearns: Amer. Naturalist, XIII, 413, f. 1–7; Steinbrinck: Bot. Zeit., 1878, 579, pl. 13, f. 16; Wichura: Flora, 1852, 66, pl. 4, f. 1–2; Zimmermann: Jahrb. wiss. Bot., XII, 570. Also Huth: Monatl. Mitt. nat. Ver., Frankfurt, 1884, 87 pl. 2 (Just, 1884[1], 685).

On plumose fruits of *Monsonia* see Ascherson, *l. c.* The dissemination of *Pelargonium* is discussed by Delpino: Pensieri sulla Biol., 11; F. Darwin: Tr. Linn. Soc., Bot., 2 ser., I, 165, pl. 23, f. 5; Hildebrand: Jahrb. wiss. Bot., IX, 268, pl. 25, f. 39, 47–8; Mallet: Mag. Nat. Hist., IX, 23; Stearns: Am. Nat., XIII, 416; Steinbrinck: Bot. Zeit., 1878, 611; Zimmermann: Jahrb wiss. Bot., XII, 571, pl. 36, f. 25–8. In this genus the contraction of the awn depends largely upon the thickened epidermal cells, while torsion is effected by the mechanical fibres. According to Stearns, *Pelargonium* fruits are less readily self-planted than those of *Erodium*. Several observers have noticed that the fruits of *Erodium*, like those of *Stipa*, etc., are injurious to animals when eaten, and may even penetrate the flesh when they become entangled in their hair. See various places in Nature; Huth: Kosmos, IX, 277, etc.

For descriptions of the seed-coats see Marloth: Engler's Bot. Jahrb., IV, 237.

The cotyledons of a number of species are described by Godron (Rev. Sc. nat., Sept., 1877) who bases a series of groups of species on their form.

8. On the morphology of the *Limnantheae* see Baillon, *l. c.*; Almquist: Bot. Notiser, 1879, 109, etc. The movements of the stamens, referred to above, are also noted by Heckel: Comptes Rend., 1878, LXXXVII,—; Just, VI[1], 317. On the anatomy of the Embryo see Flahault: Ann. Sc. nat., 6 sér., VI, 111, pl. 3, f. 21.

9. On the leaf movements of *Oxalideae* see Baillon: Hist. des Plantes, V, 24; De Brignoli (see Morren); Bruce: Philos. Trans., 1785, LXXV, 356; Cooke: Freaks of Plant Life, 243; Darwin: Power of Movement in Plants, various places; Kölreuter: Annals of Bot., II. 2; Lynch: Journ. Linn. Soc., Bot., XVI, 231–2; Masters: Pop. Sci. Rev., VII. 26; Morren: Bull. Acad. roy. Sc. Belg., VI[2], 68, transl. Ann. Nat. Hist., IV, 388; Pfeffer: Physiolog. Untersuchungen, 1873, 74; Period. Bewegungen Blattorgane, 1875 (Just, III, 795); Pflanzenphysiologie, II, 238; Virey: Journ. de Pharmacie, Paris, May, 1839, 289, criticised by Morren, *l. c.* 70.

For phyllodia see Zuccarini: Monogr. Amer. Oxalisarten, 10, Nachtrag, 189; Hildebrand: Flora, 1875, 324, pl. 8, f. 7; Bot. Register, XXVII, pl. 41.

10. On the floral structure and pollination of *Oxalis* see Axell: Anordningarna, 12, 79, 106; Baillon: Adansonia, VII, 97 (*O. corniculata*); Bennett: Journ. Linn. Soc., XVII, 275 (cleistogamous flowers of *O. acetosella*); Caspary: De Nectariis, p. 54, f. 20 (nectary of *O. acetosella*); Darwin: Different Forms of Flowers, various passages referring to a number of species; Delpino: Ulteriori Osservazioni, II[2], 94 (nectar glands); Fournier: Fécondation, 51, 59 (cleistogamous flowers and order of dehiscence of stamens); Fritsch: Beobachtungen, 24, 25, 26 (time of opening and closing of flowers of *O. acetosella* and *O. stricta*); Henslow: Trans. Linn. Soc., 2 ser., I, 359, pl. 44, f. 13, 14; Pop. Sci. Rev., XVIII (*O. acetosella* and *O. corniculata*); Hildebrand: Geschlechtervertheilung, index; Monatsber. Berl. Akad., 1866, 369; Bot. Zeit., 1871, 415, 431; Bot. Zeit., 1887, 1, 17, etc. (heterogony or homogony of many species, and experiments on their fertilization); Meehan: Proc. Phil. Acad., 1880, 350 (cleistogamous flowers of *O. acetosella*); Michalet: Bull. Soc. Bot. France, VII, 465 (cleistogamous flowers of *O. acetosella*); Mohl: Bot. Zeit., 1863, 312 (cleistogene flowers of *acetosella*); Fritz Muller: Jenaische Zeitschrift, 1871, 75 (*O. Regnelii* [=*O. Catherinensis*]); Rothrock: Amer. Naturalist, I, 71 (cleistogamous flowers); Soyer-Willemet: Le Nectaire, 37 (nectar glands); Thomson: Trans. Bot. Soc. Edinburgh, XIV, 102 (*O. corniculata* and *O. Magellanica* in New Zealand); Trelease: Amer. Nat., 1882, 13 (*O. violacea*); Treviranus: Bot. Zeit., 1863, 147 (cleistogamous flowers of *O. acetosella*).

11. On the seed structure and dissemination of *Oxalis* see Baillon: Adansonia, XI (Just, IV, 461, 503); Hist. des Plantes, V, 24; Bischoff: Lehrbuch der Bot., II[1], 471); De Candolle: Physiol. Vég., II,—; Errera and Gevaert: Bull. Soc. Bot. Belg., XVII, 96, 98; Elrod: Amer. Naturalist, XIII, 95; Hildebrand: Jahrb. wiss. Bot., IX, 236; Lohde: Entwick. und Bau Samenschalen, 17, pl. I, f. 10; Marlott: Engler's Bot., Jahrb. IV, 243; Nobbe: Handb. Samenkunde, 450, 487; Peck: Plants of Mount Marcy (1880), 406; St. Hilaire: Plantes usuelles des Brasiliens, pp. 3–4 of text to pl. 43; Zimmermann: Jahrb. wiss. Bot., XII, 573, pl. 36, f. 33; Zuccarini: Nachtrag Amer. Oxalisarten, 193. Also, Gibson: Harper's Mag., Oct., 1885, 688; and Lojacono: Nuovo Giorn. Bot. Ital., XIV, 97 (Just, 1882[1], 521, where exalbuminous *Oxalis* seeds are discussed.

The histology of the embryo is discussed briefly by Flahault: Ann. Sc. nat., 6 sér., VI, 115.

12. On the general histology of *Impatiens* see Beyse: Nova Acta Leop.-Carol. Acad., XLIII, 181.

The foliar (extranuptial) nectar-glands are considered by Bonnier: Ann. Sc. nat., 6 sér., VIII, 98; Delpino: Prodr. Monog. Piante formicarie, 1886, 36; Kerner: Flowers and their Unbidden Guests, 137; Reinke: Bot. Zeitung, 1874, 59; Jahrb. wiss. Bot., X, 162.

For the pollination of the genus see Allen: Proc. Essex Inst., IV, 53 (humming birds at *I. fulva*); Axell: Anordningarna (cleistogamy, 12, 79; protandry, 106); W. W. Bailey: Bull. Torrey Bot. Club, VI, 173 (perforation of *I. fulva* by *Bombus*); Baillon: Bull. Soc. Linn., Paris, 1881, 286 (Delpino: Rivista Bot., 1881, 37; Just, IX[1], 518) (*I. Humboltiana* pollinated by birds); Beal: Am. Nat., XIV, 201; Bennett: Journ. Linn. Soc. Bot., XIII, 147, pl. 3 (Journ of Botany, IX, 376); Pop. Sci.

Rev., 1873, 345; Journ. Linn. Soc., XVII, 276 (cleistogamous flowers of *I. nolitangere* and *I. fulva*); Darwin: Cross- and Self-Fertilization, index; Different Forms of Flowers, 328; Delpino: Fecond. Piante Autocarpee, 30 (*I. balsamina*); Ulteriori Osservazioni, II^2 (early falling of anthers, 163, 172; *I. scapiflora*, etc., pollinated by Lepidoptera, 274; *I. nolitangere* bird pollinated, 336); Desvaux: Le Nectaire, 103 (nectary); Errera and Gevaert: Compt. rend. Soc. Bot. Belg., XVII, 96 (cleistogamy); Gravis: Compt. rend. Soc. roy. Bot. Belg., Oct. 9, 1880 (cleistogamous flowers of *I. nolitangere*); Gray: Genera Pl. U. S., II, 134; Amer. Journ. Sci. and Arts, 3 ser., XIV, 497 (cleistogamous flowers); Henslow: Pop. Sc. Rev., XVIII,—; Trans. Linn. Soc., Bot. 2 ser., I, 360 (*I. parviflora* self-fertile); Hildebrand: Farben der Blüthen, 18 (color-variations in *I. balsamina*); Geschlechtervertheilung, 18 (protandry); A. de Jussieu: Monogr. Malpighiacées, 1845, 85 (cleistogamous flowers discovered by Weddel); Von Mohl: Bot. Zeit., 1863, 313 (cleistogamous flowers of *I. nolitangere*); Locke: Bull. Soc. bot. de France, XXIII, 367 (cleistogamy); Müller: Befruchtung der Blumen, 170; Weitere Beobachtungen, 219; Fertilization of Flowers, 160 (*I. nolitangere*); Snyder: Amer. Nat. XIV, 126 (*I. fulva* bird-pollinated); Trelease: Bull. Torrey Bot. Club, VII, 20 (perforation of *I. fulva*); Weddel,- see Jussieu.

The dissemination of *Impatiens* is considered by Bischoff: Lehrbuch der Bot. II^1, 470; Hildebrand: Jahrb. wiss. Bot., IX, 238; Lohde, *l.c.*; Nobbe: Handb. Samenkunde, 487, etc.

For the structure of the seed-coats see Lohde: Entwickelung und Bau einiger Samenschalen, Inaug. Diss. Leipzig, 1874, 14, pl. 1, f. 6–9; Strandmark: Bidrag till Kännedomen om Fröskalet's Byggnad., Akad. Afhandl., Lund, 1874, 29, f. 23.

The histology of the embryo is described by Flahault: Bull. Soc. bot. de France, XXIV; Ann. Sc. nat., 6 sér., VI, 111; Gérard: Ann. Sc. nat., 6 sér., XI, 298, 331, pl. 16; Reinke: Unters. ü. Wachsthum und Morphol. der Würzeln, 1871.

13. The principal literature concerning the pollination of *Pelargonium* will be found in Beal: Amer. Naturalist, XIV, 126 (visits of humming-birds); Darwin: Cross- and Self-Fertilization, various places, and Origin of Species, 145; Delpino: Ulteriori Osservazioni, II^2, (papilionaceous flowers of *P. rutaefolium*, 72, 78, 262; protandry of umbels, 158; early falling of anthers, 163; *P. nocturnum* and *lobatum* moth-pollinated, 274–5; visits of birds, 334) [see also Bot. Mag., XLV, no. 1986, on nocturnal fragrance]; Fecond. Piante Antocarpee, 30; Difesa Dicogamia, 212; Fournier: Fécondation, 118 (protandry); Henslow: Trans. Linn. Soc., 2 ser., I, 358–9; Mirbel: Physiol. végét., 269, pl. 42, f. 6 (nectary); Roth: Beyträge, 1783, II, 70 (nectary); Soyer Willemet: Le Nectaire, 37 (nectary); Sprengel: Entdeckt. Geheimniss, 340–4 (*P. lacerum*, *zonale* and *quercifolium*); Trelease: Amer. Bee Journal, 1880, XVI, 137 (structure of nectary, with figures of papillae); Amer. Naturalist, XIV, 362 (visits of birds); Wallace: Tropical Nature, 275 (self-fertile island species); Weihe: De Nectariis, 26, 39 (nectary); Westwood: Modern Classification of Insects, II, 541 (visits of *Pangonia rostrata* to flowers).

In addition to the references on fruit given above see Delpino: Pensieri, 11; Stearns: Amer. Naturalist, XIII, 416, on dissemination; and Strandmark: Bidr. Känned. Fröskalet's Byggnad., 29, on seed-coats.

For the most important literature relating to the pollination of *Tropaeolum* see Behrens: Flora, 1879, XXXVII, 25, 145–153, pl. 3 (nectary); Darwin: Cross- and Self-Fertilization, index; Delpino: Ulteriori Osservazioni, II^2, (*T. tricolor*, 251; *T. majus*, 265); von Freyhold: Nova Acta Leop.-Carol. Akad., XXXIX, no. 1 (*T. pentaphyllum*); Lubbock: British Wild Flowers, 75 (*T. majus*); Meyen: Secretionsorgane, 52 (nectary); Sprengel: Entdeckt. Geheimniss, 213 (*T. majus*). On the seeds, see Hofmeister: Embryobildung der Phanerogamen, 93, and Strandmark: Bidr. Känned. Fröskalet's Byggnad., 30.

EXPLANATION OF PLATES.

PLATE 9. FOLIAGE OF GERANIUM.

Figs. 1–2. G. maculatum: 1, radical; 2, cauline. 3. G. erianthum: cauline. 4–5. G. incisum: 4, radical; 5, cauline. 6–8. G. Richardsonii: 6–7, radical; 8, cauline. 9. G. Fremontii: five leaves, the upper two radical, the others cauline. 10. G. caespitosum: two leaves, the left-hand, radical. 11. G. Hernandezii: two cauline leaves. 12. G. Sibiricum: cauline leaf. 13. G. Carolinianum: two leaves, the upper radical. 14. G. pusillum: three leaves, the lowest radical and exceptionally large, the others cauline. 15. G. dissectum: cauline leaf. 16. G. rotundifolium: cauline leaf. 17. G. columbinum: cauline leaf. 18. G. molle: two cauline leaves. 19. G. Robertianum: cauline leaf.—All reduced one-half.

PLATE 10. GERANIUM AND ERODIUM.

Figs. 1–11. Geranium: 1, G. Richardsonii; 2, G. Carolinianum; 3, G. pusillum; 4, G. maculatum; 5, G. molle; 6, G. caespitosum; 7, G. columbinum; 8, G. erianthum; 9, G. rotundifolium (the summit of the beak a little too short); 10, G. Robertianum; 11, G. incisum.—All × 2.

Figs. 12–18. Erodium: 12, E. macrophyllum, two leaves, carpel and seed; 13, E. Texanum, three leaves, carpel, and seed; 14, E. malachoides, two leaves, carpel, and seed; 15, E. ciconium, leaf; 16, E. botrys, three leaves; 17, E. moschatum, leaf, carpel, and seed; 18, E. cicutarium, leaf, carpel, and seed.—Leaves reduced one-half; carpels × 2; seeds × 5.

PLATE 11. OXALIS.

Fig. 1. O. dichondræfolia: leaf and seed (the latter surrounded by its outer envelope). 2. O. Berlandieri: leaf and seed. 3. O. Wrightii: leaf and seed. 4. O. corniculata: leaf; *a*, stipules of two leaves (magnified). 5. O. corniculata, var. macrantha: leaf. 6. O. recurva: leaf. 7. O. acetosella: leaf and seed. 8. O. acetosella, var. Oregana: leaf. 9. O. trilliifolia: leaf and seed; *a*, cross-section of seed. 10. O. violacea: leaf; *a*, two leaflets of the common form of the prairie states. 11. O. divergens: leaf. 12. O. latifolia: two leaflets. 13. O. vespertilionis: two leaflets. 14. O. decaphylla: three leaflets and seed.—Leaves reduced one-fourth; seeds × 20.

PLATE 12. SEEDS OF GERANIUM AND IMPATIENS; FRUIT OF LIMNANTHES AND FLOERKEA.

Figs. 1–14. Geranium: 1, G. incisum; 2, G. Richardsonii; 3, G. caespitosum; 4, G. rotundifolium; 5, G. maculatum; 6, G. Carolinianum; 7, cross-section of same; 8, G. Carolinianum, var. Texanum; 9, G. columbinum; 10, G. pusillum. 11–12, G. Robertianum: 11, detached segment of ovary; 12, seed. 13–14, G. molle: 13, seed, 14, the same in segment of ovary. 15. Impatiens pallida: *a*, cross-section. 16–19. Limnanthes: 16–17, L. Douglasii; *a*, cross-section; 18, L. Macounii; 19, L. alba. 20. Floerkea proserpinacoides.—1–14, × 20; 16–20, × 10.

V. The Taconic of Georgia and the Report on the Geology of Vermont.

By Jules Marcou.

(Read May 4, 1887.)

CONTENTS.

I. Introduction . . . . . p. 105
II. Sections around Parker quarry at Georgia. The Lorraine shales *versus* the Hudson River group. The suppressed Emmons' Agricultural and geological map of the state of New York. Colony . . . . p. 107
III. Age of the red sandrock, and section near Swanton . . . . . p. 114
IV. The supposed overlying great fault of the Georgia formation. The section at Charlebourg near Quebec. Landslides at Montmorency and Indian Lorette Falls . p. 116
V. The Report on the Geology of Vermont. The classification and nomenclature of Messrs. E. and C. H. Hitchcock . . . p. 119
VI. Historic classification and use of the name Georgia, with some paleontological remarks and some notes on the Graptolites zones of America . . . . . p. 122

I. Introduction.

THE geology of the eastern region of Lake Champlain and of the whole band of country extending from Albany and Poughkeepsie on the Hudson River, varying in breadth from ten to forty miles eastward and extending north to Quebec, Trois Pistoles and Cape Gaspé, is, by far, the most difficult and complicated that I have met with during my forty years' researches in both hemispheres. Nothing, even in the central Alps, is so puzzling and intricate.

The slates predominate as a general fact, but there are enclosed among them lenticular masses of ordinary limestone, marble, magnesian limestone, calcareous sandstone and pure sandstone, varying in size from that of the fist to small islands or even mountains 2000 feet long and 1000 feet broad. At first sight the slates are too uniform to permit of establishing stratigraphic divisions and easily recognized groups; and the lenticular masses of limestone and sandstone appear so suddenly from place to place, with such capricious distribution, that instead of being a help in the classification, they are, on the contrary, a constant cause of error and considerably increase the difficulties.

The sections are rarely very clear, and require more than ordinary caution in their surveys and interpretations. Paleontology must be used with a large margin for anomalies. Singular apparitions of forms, which otherwise are trusted as sure indications of certain groups of strata, are very likely to mislead, if not taken carefully with all the surrounding circumstances attending their position in the rocks. It is more difficult to arrive at the truth about fossils from some parts of the Taconic system than from any other system of rocks in the scale of geological formations. Even the colonies of Bohemia, first discovered and described by Barrande, in the second fauna (Cambrian) of fossils of the third fauna (Silurian), seem easier to work out and to accept. We must be contented

at first to study very minutely and patiently every square yard, stratigraphically as well as paleontologically and lithologically, at all the localities or special points presenting puzzles or anomalies; and, if the results are not entirely and fully satisfactory, we must not be too hasty in giving an explanation and in synchronizing with groups of strata regarded as typical. Nothing is so easy as to explain by faults, foldings, transverse upthrow, dislocations, overturns, overlaps, troughs, etc., but the true difficulties remain untouched notwithstanding, and we are obliged to return later to the slow process of patiently repeated observations, on the spot, turning and re-turning every fact, neglecting nothing and trying to explain rationally all that do not agree with the too hasty conclusions first arrived at.

However, as in all sciences, one good and original observer is able to combat all others, and, after all, the efforts of combined and very strong opposition only temporarily prevent the truth from being accepted. Their triumph is of short duration even if it extend through forty years and more, as is the case with the Taconic system.

Dr. Emmons discovered in 1838 the oldest series of sediment, which he described in 1842 as a special system independent of all others.[1] At first no fossils were discovered, but two years later, fossils peculiar to it were found, and the "Taconic system" was finally proposed as forming the base or first step of the column of formations, in which geologists have divided the stratigraphical history of the earth.

From that moment, the most active members of the "Association of American Geologists" took upon themselves to oppose by all means the acceptance of the Taconic system. This united opposition very soon became personal, and notwithstanding the death of some of their contemporaries, Dr. Emmons included, it has remained such, being transferred to Mr. Marcou, as soon as Dr. Emmons disappeared from the field, at the end of 1860.

As a rule all the observations and publications of Emmons and Marcou have been ostracized and regarded as *a priori* false and unacceptable. On the contrary, all that is said by the opposite party is received with consideration and even "with great pleasure."[2]

[1] Previous to Emmons' researches and classifications, several essays, all more or less exclusively mineralogical, have referred the rocks of the Taconic region to what was then considered as the "geological nomenclature for North America." Maclure, Cleaveland, Dewey, Eaton, E. Hitchcock and a few others collected facts and specimens, and between 1809 and 1836 they published papers, geological maps and sections, giving all their views as they understood the question with their limited knowledge and the very imperfect tools they had in their possession.

Vanuxem, however, is the first who referred the rocks of New York as *Transition* in his memoir, "On the classification and characters of American rock formation" (*Amer. Journ. Sc.*, 1829, XVI, 254); and it is only from that discovery of the exact and true age of the great formations of New York that anything worth recording as classification and nomenclature can be quoted.

Eaton's and Dewey's views are only mere expedients, showing their good will, even their enthusiasm, as collectors of specimens and as teachers, but that is all; and to try at this late hour to claim for them any share in the classification of the older paleozoic rocks is not justifiable and merely serves to diminish the rightful credit due to the discoveries of Vanuxem and Emmons. For more details concerning Maclure's, Dewey's and Eaton's views, see my paper, "American geological classification and nomenclature," which will soon be published.

[2] See *Quart. Journ. Geol. Soc. London*, 1882, XXXVIII, 408, in the "Discussion" at the end of Mr. J. D. Dana's paper, "On the geological age of the Taconic system."

Mr. J. D. Dana in a "Note on the age of the Green Mountains" (*Amer. Journ. Sc.*, 1880, 3d ser., XIX, 191) says: "in conclusion, the *western* half of the region between the Connecticut River valley and the Hudson River, that is, the western half of the Green Mountains area, is proved to consist of rocks that are (1) of Lower Silurian age, etc." By Lower Silurian he means the Champlain Division.

From 1872 to 1886, Mr. J. D. Dana published a dozen papers on the "Geological age of the Taconic system" (See *Amer. Journ. Sc.*, 3d series, 1872–73, 1877, 1879–82, etc., and *Quart. Journ. Geol. Soc. London*, Aug., 1882); always insisting that the Taconic schists, the quartzite and limestone, are of the age of the Hudson River group, the Trenton limestone and Chazy, and denying the existence of the Taconic system.

All this shows how hard the struggle has been. After Dr. Emmons, who bravely sustained the opposition almost single-handed during eighteen years, had disappeared forever, I came to the rescue and for twenty-seven years I have struggled, almost alone, in the same cause. How far I have succeeded, it is not for me to say. Having carried so long the whole burden on my shoulders, I know only too well how heavy it has been, and that my adversaries were not always very fair in their opposition. However, the time seems to have arrived for more just and less passionate discussion, and more steady progress is now at hand.

The United States Geological Survey has a splendid field of operation. It has already begun in earnest, and, after some unavoidable wavering in handling such a difficult question and as a first result, not only has it recognized the existence of the Taconic system, but the geologist who has charge of the work accepts already two-thirds of the strata described by Emmons — that is to say, eighteen thousand feet of strata containing a part of the primordial fauna—as certainly Taconic. One-third, about five or eight thousand feet, "the black slates, Stockbridge marble and sparry limestone," remains as debatable ground.

From my own researches in the Lake Champlain region and around Quebec city, I have not the smallest doubt as to the propriety of including also those stratified rocks as the upper part of the Taconic system and below the Potsdam sandstone. It is now a question of time, and in a few years the whole original Taconic system, as proposed by Dr. Emmons, will be accepted and regarded as the most precious jewel in the crown of American geology.

We have now to wait for minute surveys of the region embraced between central New York, Quebec, the Green Mountains, the Taconic range and the Hudson River. With all the resources of practical stratigraphy, paleontology, lithology, good topographical maps, detailed sections, geological maps surveyed with great care and exactness, the U. S. Geological Survey will complete a most important work, for it will be the base absolutely necessary for the geology of all the eastern, northern, southern and central part of North America; and, as a pioneer, who during many years of hard and solitary toil has seen the difficulties and has never despaired of the Taconic cause, I salute with joy the arrival of new observers, better fitted out and armed than I was, sure that now the truth will not be kept much longer in the background.

II. Sections around Parker quarry at Georgia. The Lorraine shales *versus* the Hudson River group. The suppressed Emmons' agricultural and geological map of the state of New York. Colony.

In 1880, I published a *résumé* of my researches around the northern part of Lake Champlain, under the title: "Sur les colonies dans les roches Taconiques des bords du lac Champlain" (*Bulletin Soc. Géol. France*, 3e sér., IX, 18), with a detailed geological map, covering the classical ground of Chazy, Isle La Motte, Georgia, Swanton, Highgate and Phillipsburgh, and several sections in the text and on one plate.

My observations were made at intervals between 1849, 1861 and 1874; and I know that several portions of the country comprised in my map needed a careful revision in the field. But travels and very grave illness prevented me from finishing the work, as

I had intended. However, I concluded to publish my observations as they were, in order not to lose them, notwithstanding my absence from Cambridge—I was then at Salins (Jura)—and the want of a reference to my specimens, and with only a part of my note-books in hand, trusting to my memory more than was prudent. So it is not surprising that I have made some mistakes, and did not give my observations as accurately as they appeared in my note-books, more especially the notes taken in 1861, which were left in Cambridge.

The important memoir of Mr. Charles D. Walcott, "Second Contribution to the studies on the Cambrian faunas of North America" (*Bulletin U. S. Geol. Surv.*, No. 30, Washington, 1886), corrects me in two instances where I have made errors, which were contrary to all of my observations made in 1861, as entered in my note-book. The errors on my part are no less true, and I thank Mr. Walcott for his corrections.

The first is a lenticular mass of calcareous sandstone enclosed in the cliff of Parker's farm, a little north of the quarry. By mistake, I have given a section on page 24 of my memoir, representing a deposit of Potsdam sandstone or red sandrock lying in a sort of depression or hollow upon the Georgia slates. Mr. Walcott has demonstrated that it is a lenticular mass containing the same fossils, *Olenellus*, *Bathynothus*, *etc.*, as the Georgia slates. He kindly refers to a letter I wrote him, December, 1885, correcting my error and giving him a copy of my section as I find it in my note book of 1861. I give it now, Plate 13, fig. 1. The lenticular sandstone is enclosed by folded slates around it except on the top. Its dimensions are: 45 feet in length and 20 or 25 feet in thickness. Several loose pieces lie at the foot of the cliff. I did not find fossils. The dip of the strata varies, according to places in this section. At the lenticular mass, the dip is only 12°; at the bending of the arch, forming the middle part of the quarry, the slates and sandstone dip 35° to the east, but at the south and in the depression towards Parker's house, the black slates dip only 10°.

The second error corrected by Mr. Walcott is more important. In my section, Plate II, fig. 1 (*Bulletin Soc. Géol. France*, 1880, IX), from Lake Champlain to Parker's house and the village of Georgia, I have considered the red sandrock, east and west, that is to say, on each side of the "Olenellus zone" of Parker's quarry, as Potsdam sandstone. Mr. Walcott has shown conclusively by direct superposition of the Georgia slates over the red sandrock, and by finding fossils, such as *Olenellus Thompsoni*, *Kutorgina*, *Obolella*, *etc.*, that at least the first three hundred feet west of the Parker quarry belong to a lenticular mass of reddish-pink dolomitic limestone and arenaceous limestone enclosed in the Georgia slates, and consequently are a part of the Georgia formation.

I must say that such was my first impression and in my field notes of 1861, I have drawn a section similar to the one given by Mr. Walcott. I cannot find in my several note books of 1862–63 and 1873 any justification for the change I made in my first section, which I now give (Plate 13, fig. 2), only I remember that at one of my last visits, a deep ditch of four or five feet had just been dug for drainage close by the eastern edge of that dolomitic limestone formation, and in such a position in regard to the dipping of the red sandrock that, if the limestone were enclosed in the slates and overlaid by them, the ditch ought to have reached the red sandrock, but it did not; and, very likely, I concluded that they were Potsdam sandstone, lying in discordance of stratification over the Georgia slates. Besides I did not find any fossils.

Let me say here, that to find fossils in those lenticular masses of dolomitic limestone and sandstone, at or near Parker's quarry, was not an easy task; for this place has been searched throughout its whole area, and very carefully, by Dr. S. H. Hall, Rev. J. B. Perry, E. Billings, Colonel Jewett and myself; and to come after such observers and detect fossils where no one of us found any, is a feat of no common occurrence. Mr. Walcott has shown himself there, as he has also at several other places in the vicinity of Georgia, Swanton and Highgate, at Trenton Falls, Saratoga, the Great Cañon of the Colorado, Eureka, etc., etc., to be the ablest collector of fossils in America, and one of the first the world over. I am glad to have this occasion to state my admiration for his keenness, persistence and extraordinary ability for finding fossils. It is a rare and very precious gift.

The Lorraine shales versus the Hudson River group.—Having acknowledged the errors corrected by Mr. Walcott, I have now to offer some remarks upon points on which we disagree.

Comparing his section, pp. 15, 16 and 17 of his "Second Contribution to the studies on the Cambrian faunas of North America," with mine, there are first the slates on the shores of Lake Champlain. Mr. Walcott, in his "Georgia sections," p. 16, fig. 1, calls them *Hudson River formations* dipping 60° east. But he gives no explanations and even in his "Ideal section from the Adirondacks over the line of the Georgia section," p. 25, fig. 2, no Hudson River formation is given.

Since my first paper, published in 1861, I have carefully avoided the use of the name "Hudson River group," which has become so hopelessly involved. The confusion created by its use, with its many meanings, must be checked, and the sooner the better. Mr. S. F. Ford in 1885 ("Observations upon the great fault in the vicinity of Shodack landing," in *Amer. Journ. Sc.*, XXIX, p. 16) has also rejected the designation "Hudson River group," using instead the old synonym "Lorraine shales."

One of the first *desiderata* is a careful survey of the typical localities of the Lorraine shales at Sandy Creek, on Lake Ontario. Then the shales should be studied in all central New York as far as Utica, and the old opinion first expressed by Dr. Emmons of a union of the Utica slates and Lorraine shales, on account of the uniformity of the lithological characters throughout the rock, should be controlled. The fauna at Sandy Creek and through central New York of the "Utica and Lorraine" would require the attention and careful studies of an excellent paleontologist as well as a good stratigraphist, like Mr. Walcott. From Utica to Schenectady, the survey should be very minute; and then, as soon as the valley of the Hudson is reached near the mouth of the Mohawk, where the Lorraine shales have been crushed and strongly laminated by lateral pressure, probably it would become necessary to put aside all the slates which do not contain a full fauna — at least two-thirds or certainly a good half of the number of species of the Lorraine of central New York.[1] We should then synchronize only the portion of the

[1] "The typical rock (Lorraine shales) is displayed in the gorges of Lorraine and Rodman, and not upon the Hudson River. In the latter region the rock is crushed, and is by no means in a condition suitable to give character to a group, hence it should be referred to only as a modified condition of the Lorraine shales."

"On the Mohawk at Cohoes, the shales and sandstones in a crushed condition are tolerably well exposed. They may be traced to Schenectady and Saratoga, where they lie in a horizontal position" (*American Geology*, Vol. I, Part II, Taconic System, by E. Emmons, p. 140, Albany, 1855).

shales found in the Hudson River valley, with the "Utica and Lorraine" which actually contain the fauna of Sandy Creek, with its Acephalae (Lamellibranchiae) and its characters of the upper part of the second fauna (Cambrian) containing forms already foreshadowing the advent of the third fauna (Silurian).

Such a survey would diminish, considerably, what is still called in eastern New York the Lorraine shales (Hudson River group), and reduce them to smaller dimensions in thickness as well as in area. The old "black shales group" of Dr. Emmons will have then to be considered and carefully surveyed from Poughkeepsie to Bald Mountain (Washington County), then through Vermont to Phillipsburgh and Quebec city; that is to say, all the western part of the great band of the Taconic system, so well delineated on the supposed lost map of Emmons, which was prepared by him to accompany the first volume of the "Agriculture of New York."

A few words about that map will not be out of place here.

The suppressed Emmons' agricultural and geological map.—The geological map of the state of New York, described at pages 361 and 362 of the "Agriculture of New York, Natural History of New York, Part v, Volume i," Albany, 1846, referred to in "Mapoteca Geologica Americana," p. 59, Washington, 1884 (*Bulletin U. S. Geol. Surv.*, No. 7), "as stolen or destroyed by persons unknown, so that it was never issued with the proper volume" (see letter of Emmons to Jules Marcou, Dec. 28, 1860, published in "The Taconic system and its position in stratigraphic geology," *Proc. Amer. Acad.*, xii, 188, Cambridge, 1885), has lately and unexpectedly made its appearance at the State Library and at the New York State Museum of Natural History at Albany.

About ten years ago, and consequently about fourteen years after the death of Dr. Emmons, the state librarian, on the plea that the first issue of the map of 1842 was out of print, began to distribute it as the "Geological map of the state of New York," the first two words of the title being omitted. But this year several copies have been distributed without abbreviation. The full title is, "Agricultural and geological map of the state of New York, by Legislative authority, 1844." The abbreviation made on some of the copies distributed during the last ten years consists in the cutting off of the words "*Agricultural and*," forming a first line added to the map of 1842. The table of colors and classification of rocks is the same, with the exception that the Taconic system, which does not appear in the tabular view with his name or any sort of notice, exists on the map in drab color, as a large band extending from the Canada boundary line to New Jersey and the Tappan sea on the Hudson River.

The map being hand-colored, some variation in the coloring must be expected. In the copy I have now under my eyes, the Calciferous and Black River and Birdseye limestones are confounded in a single color, pale blue; while, in the map of 1842, the colors are very distinct, the Calciferous being brown and the Trenton (Black River and Birdseye) sky-blue. Another difference exists, for the three colors of the Utica, Hudson River and Oneida, which were very distinct in the map of 1842, are mingled together, more or less, under a single gray-lilac color. Finally the Portage and Chemung groups, colored green-gray in 1842, are very pale yellow in the map of 1844.

The appearance of the long lost map of Dr. Emmons, I am glad to say, has been accompanied by the return to the state Museum of Natural History at Albany of "the rocks illustrating the Taconic system, all taken out by order" many years ago (letter

of Emmons to J. Marcou, Dec. 1860, on "The Taconic system," etc., *Proc. Amer. Acad.*, XII, 118, Cambridge, 1885).

The Lorraine shales.—So far as my own observations extend, I must say that I did not find the Lorraine shales either north or east of the Adirondacks, and that between the Georgia formation and the Potsdam group, we have in all that region of Lake Champlain and the vicinity of Quebec city, between five and eight thousand feet of shales, containing now and then lenticular masses of limestone, sometimes magnesian, sometimes pure, sometimes argillaceous. Fossils generally are rare, but they exist; only, instead of being found uninterruptedly on ledges of rocks extending for fifty and even hundreds of miles, as is usual, they are limited to special localities, and have a very short horizontal range. In fact, we have in those slates, sporadic apparitions of forms of the second fauna, inclosed in the supra-primordial fauna. About a dozen and even more, say twenty, of those fossils are identical and pass from the Taconic into the Champlain or true Cambrian,[1] and when found two or three together, or even six, eight and ten in the same place and locality, always rather narrowly limited, it has been the custom until now, among all the paleontologists and consequently among the geologists who follow their lead, to say: for the citadel and city of Quebec, it is Utica and Lorraine; for Pointe Lévis, Phillipsburgh, and Bedford, it is Calciferous and Chazy; for Highgate Springs, Swanton, St. Albans' Bay village, it is Trenton limestone, and even at Highgate Springs we have according to their views, Black River limestone, Utica and Hudson River (Lorraine). Farther south at Fort Cassin, it is Birdseye; at the foot of Snake Mountain, it is Trenton and Chazy; at Shoreham, it is Chazy; at Wappinger valley (Dutchess County), it is either Calciferous or Trenton; at Newburgh, it is Trenton; at Stockbridge marble quarry, it is Trenton; the sparry limestone of eastern New York is also Trenton; the so-called hydromica schists are Hudson River (Lorraine), etc., etc.

The extraordinary geographical distribution of these so-called Calciferous, Chazy, Birdseye, Black River, Trenton, Utica and Lorraine, without any regular connection and continuity, or superposition, makes it a little difficult to classify and account for these capricious outcrops; but faults of all sorts and all shapes are now called in to help. However, it is not sufficient, and new groups or *étages*—always of the Champlain system, but unhappily always also wanting at all Champlain typical localities—have been created, under the name of lower Calciferous, Quebec, Lauzun and Sillery groups (Logan); Lewis conglomerate and limestone conglomerate of the Quebec citadel hill (Selwyn).

But, notwithstanding all these more or less artificial helps, with the addition of shore, off-shore and deeper water deposits, it remains to be explained why, in such developed divisions of five to eight thousand feet thickness, we do not find the whole fauna, say two hundred and fifty species at least, of the Champlain system, so well developed close by at Utica, Sandy Creek, Trenton Falls, Chazy, Isle La Motte, Montmorency Falls, Charlebourg and Indian Lorette Falls, instead of finding only a dozen or twenty species. Why

[1] Less than eight per cent of the species of the primordial fauna passing into the second fauna is a small proportion, when compared with twenty per cent of the Devonian species passing into the carboniferous, or with the thirty per cent of the carboniferous passing into the Dyas, or with the thirty-five, fifty and even ninety per cent of identical species between the lower tertiary, the upper tertiary and the modern faunas. The uniformist rule — each species being always confined to divisions of the second, third and even fourth order of the strata — put forward by Alcide d'Orbigny and Louis Agassiz was never accepted by Deshayes and Lyell; and since the discoveries of Barrande, Linnarson, Broegger, Dupont, Keyser, Waagen, etc., such an empyric law has become totally obsolete.

also do we not find that great number, at least two hundred species of fossils (Lévis, Phillipsburgh, Fort Cassin, Wappinger valley)—having forms considerably similar to the forms of the second fauna—which do not exist in any of the Champlain typical localities of New York and Canada? Why have we, in some of those strange fossiliferous localities of the "Black slates" of Dr. Emmons, mixed with forms of the second fauna, fossils of the primordial fauna, such as *Olenellus*, *Dikellocephalus*, *Conocephalites*, *Camerella*, *etc.;* or fossils which have not yet been recognized with certainty in any typical localities as belonging to the second fauna, as for instance the genus *Bathyurus?* Why do we have recourse to explanations entirely erroneous to explain the mixture of the primordial with forms of the second fauna at Pointe Lévis? For the two faunas found there do not occur, one in the matrix and the other in bowlders, as it is stated by the director of the Geological Survey of Canada, Mr. Selwyn, but in the same lenticular mass of dolomitic limestone; the conglomerate which exists there, just behind the village of Pointe Lévis—Colline de la Croix—being absolutely bare of fossils. Why, finally, at Charlebourg (Plate 13, fig. 8) behind the church, on the Trèsplat, is the classical Trenton, with Black River limestone, found horizontally covering the "black slates" strongly dipping east-east-south, at an angle of 45°, showing a discordance of stratification absolutely inexplicable by overlapping fault, or any other mechanical process?

No! the truth is that, after the inexcusable mistake made by the state paleontologist of New York of placing the primordial fauna at the top and above the second fauna, and the complete ignorance of the existence of almost twenty-eight thousand feet of strata, we are now contending against another mistake, not so great to be sure, but no less an error.

Section from Lake Champlain to Parker's house.—Returning now to the section of Georgia, Plate 13, fig. 2, I continue to regard the black slates on the lake shore as belonging to the Phillipsburgh and Swanton groups. Then occur in discordance of stratification over the slates, dolomitic limestones, which are numbered 1, 2 and 3 in Mr. Walcott's section. He gives them a thickness of 700 feet. Their dips are not given; but, taken on his section, they are 24° east. He found only a single fossil, a rare *Hyolithellus*(?).

I did not find any fossil there, nor did I measure the thickness of the limestone. The dip I found only from 6° to 8° east; and I have marked on my section three shallow valleys separating those masses or groups of sandrocks in which I thought I saw some slates, but I am not sure of them, except the first one near the lake, where there is a brook of running water. In the two others, however, there is stagnant water, indicating the existence of marly slates beneath.

Numbers 4 and 5 of Walcott's section are reddish-pink dolomitic limestone and gray arenaceous limestone containing fossils: *Olenellus Thompsoni*, *Conocephalites Adamsi*, *Kutorgina*, *Obolella;* thickness, 290 feet; dip 12° east. This part of Mr. Walcott's work corrects my section published in 1880. I accept it entirely, and I repeat with pleasure it is a beautiful and difficult discovery and rectification.

Mr. Walcott considers all those dolomitic limestones from No. 1 to No. 5 inclusive, as a great lenticular mass of one thousand feet in thickness, belonging to the lower part of the Georgia formation. In my section I place also his numbers 4 and 5—or the last eastern knob of limestone—in the Georgia slates; and in my geological map of 1880, the

line ought to be drawn farther west, in order to embrace the first line of Potsdam sandstone in the Georgia division. Curiously enough, in my map, that knob is marked as a lenticular mass, limited, north and south of Parker's house, to about one thousand feet in length. Also on the same map, the two other Potsdam sandstone lenticular masses on the same line as Parker's house, ought to be included in the Georgia slates, as they belong to them according to Mr. Walcott's observations.

However, for the present, I am not inclined to accept the first three numbers of Walcott's section, as belonging to the Georgia group, and also I do not admit their supposed overlapping fault on the slates, near the lake shore. I shall discuss these points farther on, wishing to finish the description and comparison of the two sections.

The Parker's quarry forms a steep cliff, fifty feet high at the highest point. The section and description I have given in 1861 and 1880 are still the only ones and they have not been contested, except on the dip of the strata, which Mr. Walcott gives as only 12° east in his text, and in his section, p. 16, they are drawn at an angle of 35° and even 40°, agreeing then with the inclination of 35° given in my sections and memoirs.

Between Parker's quarry and the westward limestone lenticular mass, there is a small valley, quite open, less than fifty yards broad, formed by slates, on which rests a sort of lentille of blue limestone, containing two Trenton fossils (Brachiopod and Coral). The block is only one foot and a half square; it seems to have been rolled, and I have regarded it as a boulder. Mr. Walcott is of the same opinion. However, I have some doubts now as to its being a boulder; possibly it may be a colony.

Advancing eastward, above the Parker's quarry, there are slates forming a platform and then a declivity. Directly north we find the end of a lenticular mass of magnesian limestone containing Brachiopoda, about twenty feet thick, and extending from the top of the hill to the road from St. Albans' bay to Parker's farm. Their dip is 15° or 16° east. The slates in front of the limestone, on the declivity, seem to dip at 30° and 35°, but some cleavage may exist there; and it will be better to have new observations made before giving a definite dip.

Colony.—At about only twelve or twenty feet from the limestone lentille, are found several isolated slabs or flag-stone, lying on the slates, in concordance of stratification. Almost one foot thick, three or four feet in length, with sharp angles, they consist of a sort of blue limestone containing two or three fossils of the second fauna. From their position and peculiar forms, which will not admit transportation by a glacier, I regard them as surely a colony of the second fauna inclosed in the Georgia slates. In the walls near the house of Mr. Parker, some loose pieces of blue limestone, containing one or two Trenton fossils, have been seen. It is impossible to say whether they come from a boulder or from a colony near by. I have no doubt that other colonies will be found among the Georgia slates, not only in the Lake Champlain region and in Canada, but also all along in southern Vermont, in eastern New York, and in western Massachusetts.

My section fig. 2 ends a little northeast of Parker's house. I do not see any change to introduce in my former section of 1880, eastward from Parker's to the Green Mountains. Mr. Walcott has found a fault between Georgia Village or Centre and the Vermont Central railroad, and has stopped short with a blank at the foot of the first Green Mountain hill.

In the lenticular mass of limestone, marked on my geological map, between Parker's farm and Georgia Centre, Mr. Walcott has been successful in finding a few fossils: *Lingula*, *Orthisina*, *Camerella*, *Agnostus* and *Conocephalites*, which he thinks indicates perhaps the Potsdam formation. I regard those determinations of Potsdam and fault as merely conjectural, and I am convinced that the more eastward we go, after leaving Parker's farm, the older are the strata.

III. Age of the Red Sandrock, and section near Swanton.

The discordance of stratification on the western edge of the red sandrock is so well marked everywhere, and Billings was so positive as to the paleontological age, that I did not hesitate to refer the whole series to the Potsdam sandstone formation. I confess that I ought to have been more careful and more prudent with some parts of them; for I have seen at Swanton red and yellowish calciferous sandrock inclosed in the Georgia slates, and on the road from St. Albans' Bay to Parker's farm I have crossed several ledges of red sandrocks with Georgia slates intercalated in concordance of stratification. But I had so many other questions to attend to, and always thinking that I had full time to make a complete survey, that I passed it over without proper attention.

The discovery of Mr. Walcott, of the Georgia slates fauna, in some parts of the red sandrock, not only at Parker's farm, but also at Highgate Spring near Church's farm, shows that I have made a mistake. But are all the red sandrocks of Vermont a part of the Georgia slates, as Mr. Walcott seems to consider them, or some portion of them only?

The absence of a geological map from Mr. Walcott's paper leaves us in doubt as to many of his opinions; perhaps if he had tried to put his observations on a detailed map, he would have found difficulties which would have made him hesitate about some of the views presented in his memoir.

Lithologically there is a great similarity between the red sandrock of Vermont[1] and the typical localities of the Potsdam formation at Potsdam, at Keeseville, as well as in Beauharnais county (Canada). Magnesian limestone interstratified with pure sandstone or sometimes calcareous sandstone, of gray, red and pinkish colors, form the two groups, as well in Vermont as in New York and Canada. The occurrence of similar sequences of beds of the same lithological characters, and so near one another as Keeseville and Georgia, are certainly puzzling and may mislead, if not properly checked by paleontological and stratigraphical facts.

Paleontologically, the finding of *Conocephalites Adamsi* in Vermont, so nearly related to *Conocephalites minuta* of Keeseville, was in favor of identification of the two formations. But there is more. I have collected in the section of Swanton, on the ground of Doctor Hall's farm (now Bullard's farm) in the pinkish-red sandrock, an imperfect glabella of *Conocephalites minuta;* and Mr. Walcott signalizes a *Lingula*[2] in

[1] The red sandrock of Vermont is generally formed of a limestone containing a little sandy matter, and is almost always magnesian or dolomitic. It has often a globular structure, which gives to some of the beds the form of a pudding or even of a breccia; and the marble manufacturers of Swanton have taken advantage of the varieties of colors given by that structure to work largely for the trade several strata in the vicinity of Swanton and St. Albans.

[2] "Second contribution to the Cambrian faunas of North America," p. 19.

a limestone conglomerate or breccia, and *Lingulella* in the shales at the same place. My specimen of the head of *Conocephalites minuta* was determined as such, in 1881, by Mr. Whitfield, and is at the American Museum of Natural History at New York. I did not pay any attention, at the time of finding it (in 1862), as to what part of the section it belonged; but it came from that place without a possible doubt.

We must say that the *Conocephalites Adamsi*, confined, for many years, to the single locality of Church farm where it is generally found in loose pieces of very pinkish-red sandrock, has been collected by Mr. Walcott in many other places, and seems to range through at least fifteen hundred feet of magnesian limestone, slates and sandstone at Highgate Spring and at Georgia. Until now, it is certainly the primordial fossil which possesses the greatest range, carefully recorded, of all those found in the Taconic of Vermont.

Stratigraphically, the red sandrock is seen in such position at different places,—for instance, on the shore of the lake at Highgate Spring, Highgate Falls, Swanton, St. Albans' Bay and Shelburn Falls, that it left no doubt as to its being an overlying formation which, according to J. B. Perry, "in several instances, extends over almost the entire, if not over the whole, width of the Taconic series of Dr. Emmons."[1]

The existence of lenticular masses of magnesian limestone and calcareous sandstone, inclosed in the Georgia slates, is certain from the observations of Mr. Walcott at Parker's quarry and at Highgate Spring (Church and E. Stearns's farms). I shall add my observations at Swanton, on the ground of Dr. Hall's farm, where I saw in 1862 the following section; Plate 13, fig. 3. It began at the Missisquoi river, running east-east-south, passing first at the small Sugar cabin and then over the two lenticular masses of blue and gray limestone.

1. Sandy alluvial; 15 feet.

2. Red sandrock, massive, passing to a red magnesian conglomerate; almost horizontal, the dip being only 1° or 2° east. No fossils; 30 feet.

3. From the Sugar cabin to the summit of the first hill an alternance of Georgia slates with beds of gray, reddish and yellowish calcareous sandstone; about 200 feet. Dip 12° to 15° east. Fossils: *Olenellus Thompsoni*, *Camerella antiquata*, *Conocephalites*, *etc.*

4. A first lenticular mass of a very hard blue limestone, brecciated, of only thirty feet of diameter, containing a great quantity of fossils, more especially *Obolella* (*Kutorgina*) *cingulata*, *Orthisina*, *Camerella* and *Conocephalites*.

5. A little southeast, separated from No. 4 by black slates containing *Olenellus Thompsoni*, *Conocephalites Teucer*, *etc.*, there is a second lenticular mass of another very hard limestone, whitish-gray, with veins of carbonate of magnesia; containing also numerous fossils: *Olenellus Thompsoni*, *Conocephalites Teucer*, *Kutorgina cingulata*, *etc.* The part that crops out is larger than at the first lentille and shows a diameter of fifty feet.

6. Black slates with some beds of sandstone containing *Palaeophycus*. The slates are cleaved and in some places I have seen a difference of 35° between the cleavage and the stratification. The largest specimen of *Olenellus Thompsoni* I have ever seen was found there and it shows finely the cleavage; it can be seen at the American Museum of Natural History of New York, to which I have given some of my best specimens.

[1] "Queries on the Red Sandstone of Vermont, etc.," p. 6, Boston, 1868.

7. Red sandrock forming the top of the hill. I did not make any observations on that part of the section, nor farther east, where are seen other slates and red sandrock hills.

I have referred the red sandrock near the Missisquoi river, No. 2, as belonging to the Potsdam, and I see nothing in what has been published by Mr. Walcott to change my view. As to the other expositions of red sandrock, marked No. 7, and farther east, I cannot give any decided opinions; they need to be carefully examined before any conclusion can be reached. Perry says "In some cases, the Black or Swanton Slate (comprising also the Phillipsburgh group) may be seen beneath the Potsdam sandstone (red sandrock), not only along its western flank, but also at the very edge of its eastern limits. After long searching, I was at last so fortunate as to find the two rocks thus situated and in immediate conjunction. This was on the easterly border of the sandstone, at Shelburn Falls, where, some years ago (in the summer of 1860) an excavation was made in the channel of the La Plot river. Since that time, I have observed substantially the same thing at many other points. So the Georgia Slate may be traced beneath the Potsdam sandstone (red sandrock) with equal clearness and shown to underlie it, in its extreme extension eastward in Swanton."[1]

There is no reasonable doubt that some portions of the red sandrock are younger than the Georgia slates or formations and belong to the Potsdam sandstone. But the opinion expressed by Mr. Walcott has also incontestably some basis, and the question must be met by a new and very careful survey.

My opinion is that two-thirds of what is generally called red sandrock belongs to the Potsdam formation, and that one-third only is a part of the Georgia formation. I am inclined to believe that those two different ages of red sandrock are in juxtaposition on some part of the line of the outcrop of the Georgia formation. I think that a difference in the dip of the two series is well marked by an angle of 10° or even 14°. On the western side of the red sandrock line, the dip is very small, the strata being almost horizontal, or varying from 1° or 2° to 6° or 8° at most; when, on the contrary, the red sandrock, clearly belonging to lenticular masses inclosed in the Georgia slates, has an eastern dip of 12° to 16°.

IV. The supposed overlying great fault of the Georgia formation.—The section at Charlebourg near Quebec.—Landslides at Montmorency and Indian Lorette Falls.

I have previously said that Mr. Walcott regards the discordance of stratification on the western limit of the red sandrock as due to an overlapping fault of the Georgia formation, which covers what he calls the Hudson river group, Trenton or Chazy, according to localities. He thinks that the massive red sandrock was pushed over on the slates, and consequently that the slates have been crushed, strongly compressed and forced under the red sandrock.

The break and dislocations of the Taconic rocks are very great and the slates show everywhere strong lateral pressure by their cleavage and their contorted and faulted

[1] "Queries on the Red Sandstone of Vermont, etc.," pp. 10 and 11, Boston, 1868 (Ex. from *Proc. Bost. Soc. Nat. Hist.*, xi.)

structure. I have already given an example of the folding with fault of the Swanton slates, which is seen just below the bridge of Swanton Falls, the contorted slates being cut also by small local and very limited faults (see "Sur les colonies dans les roches Taconiques des bords du lac Champlain," in *Bulletin Soc. Géol. France*, IX, 29, Paris, 1880). I shall now give several other examples.

At Parker's quarry, Georgia, near the top of the section, fig. 1, just above the main range of *Olenellus Thompsoni*, in a sandy limestone with nodules of red iron, there are small contorted beds made by strong pressure, as represented by fig. 4 on Plate 13.

At Highgate Falls, in the lenticular mass of limestone, there are numerous contorted beds of brecciated limestone, as seen on Plate 13, fig. 5, in a distance of only fifteen or forty feet and with a thickness of thirty or forty feet. The most remarkable of these contorted structures is seen on the left bank of the Fall, between two houses built on high walls, fig. 6.

At Pointe Lévis, the cliffs show several folded and contorted strata containing a quantity of simple and compound graptolites. Fig. 7, on Plate 13, represents, near the railroad depot, just behind the Victoria hotel, the same folding observed farther east at the turning of the road from the ferry to the church of Notre Dame.

The section at Charlebourg near Quebec.—At Charlebourg, on the road in ascending from Charles river to the village,[1] we have in the Quebec-city and Citadel-hill slates or Swanton slates very numerous and complicated folding with small local faults. The slates are beautifully contorted; and behind the village at the Trèsplat, several quarries in the horizontal Trenton limestone have reached the slates, and I have seen them contorted and dipping 45° east-east-south under the almost horizontal Black River and Trenton limestone (see Plate 13, fig. 8).

Landslides at Montmorency and Indian Lorette Falls.—This section of the road to Charlebourg shows that there is no great fault at Montmorency Falls, at Petit Ruisseau and at Indian Lorette, but only small local landslides. Denudation and erosion of the slates have undermined the Trenton limestone above, and, little by little, the band of almost horizontal Champlain system has been excavated, destroyed and washed away, diminishing its breadth by one-half and even more in some places, only about one-third and probably less of what was originally deposited now remaining.

The process of destruction, underneath the slaty base, has forced the Trenton limestone and Utica slates cover to slide down, as it is now seen at Indian Lorette Falls, and on the right side of the chasm at Montmorency Falls, where some large fragments or blocks of Trenton limestone are seen suspended on the asperity of the quartzite. And at special places, like the ravine in V-shape, at the foot of Montmorency Falls, on the left, the Trenton and Utica, coming above a gully or truncated trough between the quartzite and the Taconic black slates, slid down, filling up a part of the chasm. It is a sort of fault by land slips, very limited, absolutely local and comparatively of recent occurrence. At the contact of the Utica and Taconic slates (Quebec Citadel Hill slates), the strati-

[1] The contorted slates are on the right side of the road, fig. 8, and also on the left. Between the two small faults and the village of Charlebourg, there are at least eight hundred feet of slates, but the section does not show that great thickness, the distance not being drawn to scale, for want of space.

fication is very confused and the dip of strata, which at the foot of the ravine is only 10 to 20° for the Trenton limestone, increases rapidly to 30° and 40° for the Utica slates, and to 60° and almost perpendicular for the Taconic slates.

Messrs. Logan and Selwyn have given sections in 1861: "Considerations relating to the Quebec group" (*Canadian Naturalist and Geologist*, May, fig. 1), and also in 1884: "Descriptive sketch of the physical geography and geology of the dominion of Canada," Montreal, fig. 1, of the Montmorency Falls extending to the Orleans island. Both consider all the strata between Montmorency and the eastern part of Orleans island as Trenton limestone, Utica and Lorraine (Hudson River), and Calciferous and Chazy (Quebec group) with two large faults. Mr. Selwyn goes so far as to find three large faults, one on each side of Orleans island. Those diagramatic sections of supposed structure are only speculative and have been used to settle the relations of strata of very doubtful age, and proved to be very embarrassing in the altered and finally adopted classification of the Canada survey.

Very small and limited local landslides, on the southern edge of the band of Trenton limestone and Utica slates, have been taken for a big fault. As soon as Logan saw that it was impossible to maintain any longer the age of the red sandrock, as Oneida conglomerate and upper Hudson River group, he had recourse at once to faults, which strangely enough he had failed totally to see during twenty years; and he did not hesitate to submit the strata in discussion to the most complicated folding, overlapping, upheaving and breaking. Fault upon fault with all sorts of disturbances was used most freely, in order to sustain his "Quebec group," instead of accepting openly the "Taconic system;" the only result was to create more confusion, of what was already confused enough.

These examples show sufficiently the enormous pressure exerted on all the Taconic rocks of Vermont and Canada, prior to the deposits of the Champlain system or true Cambrian. If there was on the western line of contact of the red sandrock with the slates and lenticular masses of limestone a great overlapping fault, as the slates, according to that view, have been forced under the magnesian limestone, they ought to have upheaved and raised more or less strongly the upper lip of the fault. The natural result would have been that, at the contact of the red sandrock, the beds would have been raised almost perpendicularly, as represented on Plate 13, fig. 9. But, on the contrary, at Georgia, fig. 1, at St. Albans' bay, at Swanton, fig. 3, at Highgate Fall, fig. 6, and at Highgate Springs, the red sandrock or magnesian limestone are considerably less raised, dipping only from 2° to 8°; when farther east, at some distance from the supposed fault, their dip is from 12° to 16°. At Swanton and at Highgate Falls, they lie almost horizontally on the slates and on the lenticular masses of magnesian limestone, and precisely at points where the most powerful forces must have acted in order to fold and contort, as they did, the beds of the Phillipsburg group. The conclusion that the red sandrock at Highgate Falls was deposited after the dislocation and break, and over the contorted strata of the Phillipsburgh group is unavoidable. The red sandrock at the fall, and on the left bank of the Missisquoi river, is of Potsdam age, lying in discordance of stratification over the Phillipsburgh group.

The tendency to explain every stratigraphical and paleontological difficulty by a fault is natural enough, but must be checked by direct observations; and all the objections

based on facts must be answered and explained otherwise than by the inference of a miraculous and invisible fault.

V. The Report on the Geology of Vermont. The Classification and Nomenclature of Messrs. E. and C. H. Hitchcock.

Until now I have refrained, in all my papers, to review or even to notice the Geological Survey of Vermont. Mr. Walcott having taken it as an authority, not only for the history of the Georgia formation, but also on questions of priority in nomenclature and paleontological publications; and Prof. C. H. Hitchcock's position lately taken in two publications in the *Bulletin of the American Museum of Natural History* of New York[1] and in the *Transactions of the American Institute of Mining Engineers*[2] render it necessary to give exact dates of publications, exact titles of reprinted papers in the "Geology of Vermont," and to quote the classification and nomenclature used for the strata of Vermont.

The "Geology of Vermont" is a work in two quarto volumes, containing the geological map of Vermont, published by the state of Vermont at Claremont, New Hampshire. Its title is "Report on the Geology of Vermont: Descriptive, theoretical, economical and scenographical," by Edward Hitchcock, Edward Hitchcock, jr., Albert D. Hager and Charles H. Hitchcock, published under the authority of the state legislature by Albert D. Hager. As Messrs. Edward Hitchcock and Charles H. Hitchcock are the only members of the Survey who treated of stratigraphy and paleontology, I shall only refer to them in my quotations and remarks.

These two volumes are three times antedated, and as they were not entered in the clerk's office of any district court for copyright, we do not possess any direct means of knowing their exact dates of publication. But we shall come to it within a few days by strict study of their contents and the time when they were distributed.

The Introductory or "Preliminary Report," as it is called, is dated Oct. 1, 1859 and directly an additional preliminary report is added with the date of Oct. 22, 1860 (see pp. 15, 16 and 17). Official reports are not always printed and issued at the date of presentation to legislative bodies, governors, or Congress; although the introduction is always written when the reports are completed and ready for the printers, and I would not have pointed out these two dates of the "Preliminary Report," if Prof. C. H. Hitchcock had not claimed priority for another work, "Outline of the Geology of the globe, and the United States in particular, etc.," Boston, 1853, based on the date of the introduction which, according to his opinion, ought to be accepted as the date of publication[3].

[1] "Geological sections across New Hampshire and Vermont," Art. VIII, Vol. I, No. 5, p. 155, Feb. 13, 1884, New York.

[2] "The geological map of the United States" (St. Louis meeting, Oct., 1886).

[3] See "The Geological Map of the United States" in *Trans. Amer. Inst. of Mining Engineers*, Oct. 1886, where at p. 7, Mr. Hitchcock says; "E. Hitchcock's map of 1853. The manuscript and maps were delivered to the publishers in January," is the only plea for the introduction being dated January 1, 1853, and placing it as anterior to "Jules Marcou's Map of 1853." As the two maps and books were both copyrighted at the same Clerk's Office of the District Court of the District of Massachusetts for 1853, at Boston, it is very easy to see the exact date of their publication. Marcou's map was issued on July 1, 1853, when Hitchcock's map only appeared in October, 1853, more than three months later (see also the advertisements of all the leading Boston newspapers for 1853).

In the "Geology of Vermont" there are reprints of four papers which were issued respectively in December, 1860, January, 1861, February, 1861 and November, 1861, showing it is an impossibility to claim the dates of the introduction (Oct. 1, 1859 and Oct. 22, 1860) as exact dates of publication of the work.

The third date found in the "Geology of Vermont" is at the bottom of the title page in the two volumes, and is 1861. It is also an antedate by several months of the true year. The first printed record I have been able to find of the publication is in the *Amer. Journ. Sc.*, May, 1862, xxxiii, 416, New Haven, where a review of the work is dated Montreal, March 18, 1862. The review was written on an advanced copy, for the work was not received in Boston until March 21, 1862. So the exact date of publication is the end of March, 1862.

Now that we have fixed within a few days the publication of the "Geology of Vermont" by Messrs. Hitchcock, let us notice some part of its contents. I shall only refer to what relates to the Taconic system and the Primordial Fauna.

First, all the papers by Barrande, Logan, Hall and Billings are simply reprints and not always correctly given. At p. 377, we have "Barrande's views" under the title: "On the Primordial Fauna and the Taconic system of Emmons, in a letter to Professor Bronn of Heidelberg" (*Proceed. Boston Soc. Nat. Hist.*, Dec., 1860, vii, 371). If we look at the volume referred to, we do not find any paper with such a title, but instead the following title "On the Primordial Fauna and the Taconic system by Joachim Barrande, with additional notes by Jules Marcou." These notes of Marcou are not given in the "Geology of Vermont," but a second letter of Barrande addressed to Marcou is added without reference to its recipient, leading one to suppose that it was addressed also to Bronn.

The paper by Billings, at p. 942 (appendix) is without the general title of the pamphlet, published November 21, 1861, at Montreal, which is "New species of Lower Silurian fossils." Besides, Mr. C. H. Hitchcock has suppressed, without any notice, a whole page of Billings' paper, a very interesting foot-note, pp. 11 and 12, containing among other information a letter from C. H. Hitchcock himself.

By these two quotations we see that the "Geology of Vermont" cannot be used as priority for the papers of Barrande and Billings, nor even as an exact reprint, being both defective in regard to titles and contents.

The classification and nomenclature of Messrs. E. and C. H. Hitchcock.—I shall now give quotations of the classification and nomenclature used by Messrs. Hitchcock.

Page 257: "List of the rocks occurring in Vermont in an ascending order.

Laurentian or hypozoic gneiss.
Potsdam sandstone.
Calciferous sandrock.
Chazy limestone.
Birdseye limestone.
Black River limestone.
Trenton limestone.
Utica slate.
Hudson River group.
Red sandstone series.
Quartz rock.
Georgia group.
Talcose conglomerate.
Eolian limestone.
Talcoid schists.
Upper Helderberg limestone."

Page 326: "Red sandrock series. Stratigraphically considered, this series of beds occupies the position of the Medina group of New York" (from Prof. William B. Rogers).

Page 339: "*Conocephalus* (at Highgate, directly east of the house of J. Church). The form known to me most nearly like this one is in the Clinton group of this state, New York (from Prof. J. Hall). With a shell resembling *Atrypa hemispherica* of the Clinton group of New York."

Page 357: "Georgia group. Upper Hudson River group: *Elementary Geology*, 31st edition, p. 411, by Ed. and C. H. Hitchcock, 1860."

Page 374: "Georgia slate. Its fossils rank it as Lower Silurian (Second Fauna) rather than Cambrian (First Fauna)." "The stratigraphical view of the Georgia slate which has been so ably defended by Professor Hall (James) seems to demand for it a place either above or equivalent to the Oneida conglomerate."

Page 375: "The natural inference from these relations is that the red sandrock is of the age of the Oneida conglomerate or Medina sandstone and the Georgia slate is still newer and therefore Middle Silurian."

Page 393: "Talcose conglomerate . . . is newer than the Georgia slate."

Pages 394 and 421: "Eolian limestone . . or Stockbridge limestone . . may be as recent as the carboniferous rocks." "In the middle of the limestone fossils which, though obscure from metamorphism, are clearly referable to genera characteristic of Devonian rocks."

Pages 424 and 433: "Talcoid schists are newer than the Eolian limestone."

Page 434: "The Taconic system." Mr. Hitchcock claims that the outline of its method and explanation represents Prof. Emmons' ideas "as faithfully as though we were the amanuensis of an advocate of the Taconic system." This "brief view of its history as a system" is full of reticence and even opposition, and is simply an *ex parte* and partial exposition, according to Hitchcock's understanding of the Taconic system.

The "Geological map of Vermont traced out and compiled by the members of the Geological Survey," 1861, scale of miles $\frac{1}{400,000}$, is placed at the end of the second volume, as Plate I.

"Explanation of the colors." In ascending order.

Granite, syenite and protogine.	Azoic.	Oneida conglomerate (red sandrock.)	Upper Silurian.
Gneiss.		Quartz rock.	
Hornblende schist.		Georgia slates.	
Serpentine.		Talcose conglomerate.	
Talcose schist.			
Calciferous mica schist.			
Clay slate.			
Potsdam sandstone.	Lower Silurian.	Eolian limestone.	Mostly Devonian.
Calciferous sandrock.		Talcoid schist.	
Chazy, Birdseye and Black River limestones.		Beds of limestone in talcoid schist.	
Trenton limestone.		Upper Helderberg limestone.	
Utica slate.			
Hudson River slates.		Pliocene tertiary.	
Hudson River limestones.		Gold in alluvium, etc.	

The map had two editions. The first one, distributed in December, 1861, contains the name *Oneida Conglomerate* inscribed instead of *Red Sandrock;* and the rocks are united by great groups or systems, by means of brackets under the general names of Azoic, Lower Silurian, Upper Silurian, and mostly Devonian. In the second edition accompanying the volumes, those brackets and general names are half defaced, as well as the name Oneida conglomerate. But on almost all the copies attached to the work, the erasures have been done so imperfectly, that it is easy to read those names and to see the brackets.

VI. Historic classification and use of the name Georgia; with some paleontological remarks, and some notes on the Graptolite zones in America.

Now we can give in true chronological order the history of the Georgia formation, with the exact dates of publication.

1855.—Mr. Noah E. Parker, a farmer in West Georgia, in quarrying large slates for a floor, found some trilobites. He showed them to the schoolmaster of the village, who wrote at once to the state geologist of Vermont, the late Zadock Thompson of Burlington. Thompson came directly, visited the quarry, but died in January, 1856, without publishing anything about the discovery and the geology of Georgia. However, before his death, he placed the specimens of trilobites in the hands of Mr. James Hall, with the request to publish them. I would remark that, in 1856, the primordial fauna of Barrande had been established for ten years, and several works and pamphlets had been published on the subject in Paris, in Bohemia and in Scandinavia, not to speak of the Taconic system with a special fauna recognized at first sight by Barrande as primordial, as soon as he saw Emmons' work. Twelve years had passed away since 1844, and the paleontologist of New York entirely ignored the primordial fauna, its stratigraphical position, its meaning, and the Taconic system.

1859.—Mr. James Hall, in "Twelfth Annual Report, Regents of the University of the state of New York," page 53, Albany, 1859, calls the shales in the town of Georgia, *shales of the Hudson River group*, and at page 62, he adds that Logan places "the shales of this locality in the upper part of the Hudson River group, or forming a part of a series of strata which he is inclined to rank as a distinct group above the Hudson River proper." Then Prof. J. Hall adds "it would be quite superfluous for me to add one word in support of the opinion of the most able stratigraphical geologist of the American continent."

In the article entitled: *Trilobites of the shales of the Hudson River group*, Mr. Hall describes and figures the fossils sent to him by Zadock Thompson, under the names of *Olenus Thompsoni*, *Ol. Vermontana* and *Peltura* (*Olenus*) *holopyga*.

1860 (Mar.). "Mr. C. H. Hitchcock exhibited a geological map of Vermont and explained the principal features of the complicated geology of that state." "The two most interesting points in this connection were, that there is *no foundation for what Mr. Emmons called his Taconic system* (a mixture of the Silurian and Devonian), and that the Dorset limestone (his Stockbridge limestone) is newer than the Lower Silurian, and is probably Upper Silurian or Devonian." (See *Proceed. Boston Soc. Nat. History*, Vol. VII, pp. 236, 239, Meeting of March 7, 1860.) At the same meeting Prof. W. B. Rogers

communicated the manuscript of a paper entitled: "Notes on the geological structure of western Vermont, etc.," read by him before the American Association at Albany in 1851. In it he refers the reddish sandstone and shales, and reddish, white and gray limestone as a group "belonging to the period of the Oneida and Medina rocks, to which Mr. Hitchcock now refers them."

1860 (July). Dr. Ebenezer Emmons, in the second edition of his *Manual of Geology* New York, published during the summer of 1860, in note A, page 280, calls attention to Professor Hall's remarks, in the Regents' Reports of New York for 1860, and declares that the shales referred to in northern Vermont, instead of being a new series above the so-called Hudson River group, are really sub-silurian and of the same age as the *Paradoxides* and *Olenus* primordial zone of Bohemia. (See *Manual of Geology*, page 87.)

1860 (Oct.). "Mr. Marcou made a communication on the black slate of Braintree, Mass., containing *Paradoxides*, and on similar strata in Newfoundland, near Lake Champlain and in the vicinity of Quebec," afterwards given in detail in the paper entitled: "On the Primordial Fauna and the Taconic system, by Joachim Barrande; with additional notes by Jules Marcou." (See *Proceed. Boston Soc. Nat. History*, Vol. VII, pp. 357 and 369. Published November 23, and December 24, 1860.) On page 375, Mr. Marcou uses for the first time the name *slates of Georgia*, and refers them to the Taconic system of Emmons.

1861 (Feb.). In the "Thirteenth Annual Report Regents University, New York," dated on the title page 1860 (but the true date of publication is February, 1861), Prof. J. Hall gives a new description of the three trilobites found at Georgia under another title: "Note upon the trilobites of the shales of the Quebec group in the town of Georgia, Vermont," pp. 113 to 119. We must remark, that the "title was changed in a part of the edition, by substituting the words *Quebec group* for *Hudson River group*, in deference to the views advanced by the Geological Survey of Canada." (See "Fifteenth Annual Report Regents University, New York," page 196, Albany, 1862.)

The author describes and figures the same three trilobites under new generic names: *Barrandia* substituted for *Olenus*, and *Bathynotus* instead of *Peltura* or *Olenus*, making two mistakes. First the genus *Barrandia* existed previously for another form of trilobites, having been proposed as far back as 1849 by McCoy (see *Ann. Nat. Hist.*, 2nd series, Vol. IV); and, second, the genus *Bathynotus* had been anticipated for the same fossil by Dr. Emmons, in 1860, who called it *Pagura* (see *Manual of Geology*, p. 80, figs. 5, 7 and also p. 280).

But the confusion does not stop here; for Mr. Hall proposed, in 1862, the name *Olenellus*. Recognizing that the name of *Barrandia* was untenable, he "proposes to return to the name *Olenellus*" written on the manuscript, but changed to *Barrandia* at the moment of sending it to press. Now Professor Walcott justly refers the *Elliptocephala asaphoides* of Emmons, 1844, to the same genus as the *Olenus Thompsoni;* showing that Emmons has priority, first in calling the genus in 1844 *Elliptocephala* and in 1855 *Elliptocephalus*. If it is necessary to drop *Elliptocephalus* on account of its great similarity with *Ellipsocephalus* of Zenker 1833, also a primordial genus, I think that Emmons' priority ought to be recalled in some way, and the name of the genus may be *Ebenezeria*, in honor of Dr. Ebenezer Emmons and his Taconic system.

The figure of *Barrandia* (*Olenus*) *Thompsoni*, p. 116, is much better than in the first paper of 1859, giving on the caudal shield "a slender pointed spine strengthened by a sharp elevated ridge, extending to the extremity;" but failing to give the remarkable caudal spine, more than two inches long and spade-like, which I have found on a specimen at the Parker's quarry in 1861, and which has been figured since by Mr. Whitfield in *Bulletin Amer. Museum Nat. Hist.*, New York, Vol. I, No. 5, Plate XV, fig. 1, 1884.

Another and important difference between Mr. Hall's paper on the three trilobites of Georgia of 1859 and the one of 1861 (occasioned by the publication of Barrande and Marcou's memoir in December, 1860), besides the creation of the so-called genera *Barrandia* and *Bathynotus*, is the suppression at the end, of the celebrated authoritative note on the age of the Hudson River group, and Logan's ability as a stratigraphist, which is replaced by the following note: "The geological horizon of the shales in which these trilobites occur having been made a matter of discussion among geologists, I shall refer those interested in the subject to the forthcoming report upon the geology of the state of Vermont by Prof. E. Hitchcock" (see p. 119, "Thirteenth Ann. Rep."). The nomenclature and classification contained in that report having been given previously, with the quotation of the sentence, "The stratigraphical view of the Georgia slate, which has been so ably defended by Professor Hall, etc.," it is sufficient to say that Professor Hitchcock was no more aware of the true geological horizon of those trilobites than Professor Hall, and that both had wandered astray in dealing with the paleontological and geological elements of the Georgia formation.

1861 (Sept.). Mr. Marcou in a letter to Elie de Beaumont, written during his visit at the house of N. E. Parker, Georgia, gives the first description of the *Schistes arénacés à trilobites de Georgia*, and places them as a subdivision of the *Schistes de St. Albans* in the Upper Taconic. For the first time also, he signalizes the existence of great lenticular masses of very hard limestone, badly stratified and inclosed in the slates, round the city of St. Albans. (See *Comptes Rendus, Académie des Sciences*, tome LIII, No. 19, 4 Novembre, 1861, pp. 803 to 808, Paris.)

1861 (Nov.). At the 6th of November meeting of the Boston Society of Natural History, Mr. Marcou described, with details and sections, the *Georgia slates* as the middle group of the Taconic. He gave also a history of the discovery of the fossils in the quarry of N. E. Parker. This is the first detailed description of what Mr. Walcott calls *Georgia formation*. The sections drawn on the blackboard were not published until 1880, in Mr. Marcou's paper printed in the *Bulletin Soc. géol. France*, 3e série, tome IX, p. 18: "Sur les colonies dans les roches Taconiques des bords du lac Champlain," p. 24 and Plate II, fig. 1.

The communication to the Boston Society is entitled: "The Taconic and Lower Silurian rocks of Vermont and Canada," by Jules Marcou (*Proceed. Boston Soc. Nat. Hist.*, Vol. VIII, 1861 to 1862, p. 239); and it is at pp. 244, 245 and 246, that the *Georgia slates* are described as a special group.

1862 (Mar.). In the "Report on the Geology of Vermont," by Edward Hitchcock and Charles H. Hitchcock, in two volumes, 4°, antedated 1861, but not published until the end of March, 1862, at p. 357 there is a *Georgia group*. No description of Parker's quarry or any other part of Georgia township is given.

The second edition of Professor Hall's paper on the three trilobites of Georgia, taken

from the "Thirteenth Annual Report Regents' University, New York, 1861 (not 186 0) is here reprinted from p. 367 to 372, under the title: "Note upon the Trilobites of the shales of the Hudson River group in the town of Georgia, Vermont." But the last phrase before the final note is omitted. *Per contra*, a description of a *Graptolithus Milesi* by Professor Hall is added at p. 372.

At the end of the Georgia group, p. 386, there is a Note by Edward Hitchcock expressing his doubt about Barrande's remarks in his "Documents anciens et nouveaux, sur la faune Primordiale et le système Taconique en Amérique." According to Hitchcock, Logan has suggested that "these shales and limestones (of Quebec and Georgia) are subordinate to the Potsdam sandstone" — "a deep sea deposit, going on at the same time with the arenaceous deposit near the shore; whereas Professor Emmons places his Taconic system *below* the Potsdam sandstone, in the same position as the Cambrian and Huronian system. Does he then recognize the Taconic system as understood by its author, or can it be that Barrande has mistaken his meaning?"

In the geological map of Vermont, at the end of Vol. II, Plate I, Messrs. Hitchcock, in the explanation of the colors, place the Georgia slates above the Champlain system (Cambrian), in the Upper Silurian!

Prof. C. H. Hitchcock on the "age of Taconic rocks," in a letter to Mr. J. D. Dana, dated February 10, 1880, and published in the *Amer. Journ. Sc.*, 3d series, Vol. XIX, pp. 236 and 237, says that "there is nothing in the report (on the Geology of Vermont) anywhere favorable to the Taconism." . . . "Within the past two years I have gone over most of the Vermont sections, and have felt that they demonstrated the essential equivalence of the Taconic system with the Potsdam and the overlying limestones and shales (of the Lower Silurian). I have been throughout in essential accord with you and Mr. Wing."

1862 (May). In Vol. III, *Palaeontology of New York*, Part I, Text, Albany, antedated 1859, but not distributed until the end of May, 1862, at p. 525, the paper of the *Twelfth Ann. Rep. Regents' Univ. New York*, by James Hall, is reprinted, with the altered title of: "Remarks upon the Trilobites of the shales of the Hudson River group, with description of some new species of the genus Olenus," instead of, "Trilobites of the shales of the Hudson River group," making a fourth variation in the title of that small paper, in less than three years.

In the *American Journ. Sc.*, January, 1861, p. 123, we read: "The Introduction (of Vol. III, *Palaeontology of New York*) handles with masterly skill the difficult subjects connected with the proper classification of the lower horizons of life in our planet. A review of this important chapter with reference to the views of Barrande will probably appear in our next." That review has never appeared to this day; and the introduction repeats at p. 14, the statement: "From the metamorphic slates of this group (the Hudson River group) on the western slope of the Green Mountains in Vermont, we have three or more species of trilobites, which are of much interest, being representative of a genus, but little known in this country," together with the authoritative note, containing "the testimony of Sir W. E. Logan;" and repeated *verbatim* at the end of the volume, p. 529, we have the whole "proper classification of the lower horizons of life" as understood and maintained by the paleontologist of the state of New York.

1862 (Aug.). In a printed "Letter to M. Joachim Barrande, on the Taconic rocks of

Vermont and Canada," with a "comparative tabular section," Cambridge, Mr. Marcou describes, at p. 5, the *Georgia slates* on the farm of Dr. Hall, east of Swanton, and points out two lenticular masses of very hard blue and whitish limestone, inclosed in the slates and sandstones. The fossils found in the limestone and in the slates are: *Olenellus Thompsoni*, *Ol. Vermontana*, *Conocephalites Teucer*, *Obolella cingulata*, *Orthisina fertinata* and *Camerella antiquata*.

It is in this paper that the announcement is made of the existence of lenticular masses of limestone, more or less globular, distributed without any regular order in all the different divisions and groups of the Taconic system, in Vermont as well as in Canada; and also that at Pointe-Lévis and at Phillipsburgh are found in some of the lenticular masses, *Precursory Center of Creation*, or *Colonies of the Second Fauna* inclosed in strata containing the *Primordial fauna;* a fact not recorded until then in America and showing that here as well as in Bohemia we have *forerunners* and *prophetic types*, specific as well as generic, making their appearance in a period anterior to the one in which they have obtained their full development. Mr. Marcou calls these lenticular masses, *Lenticular precursors*, in order to distinguish them from the lenticular masses containing only primordial fossils, as are those of Dr. Hall's farm at Swanton, which he calls *Lenticular primordials*.

1867.—Prof. C. H. Hitchcock, in a *Geological Map of New Hampshire and Vermont*, does not use the name *Georgia slates* nor *Georgia formation*, as he did in the "Geology of Vermont," in 1862, and in the explanation of colors, we have the following classification, in ascending order.

Laurentian.	Cambrian (Potsdam).
Montalban or Atlantic.	Coos group and calciferous mica-schist.
Huronian.	Cambro-silurian.
Kearsarge and andalusite group.	Taconic schist.
Rockingham and ferruginous schists.	Helderberg.
Cambrian clay slates.	

Another nomenclature somewhat different from the one given in his geological map of Vermont of 1861, but in which he maintains the Taconic as Upper Silurian. The township of Georgia, on the map of 1867, is colored as Potsdam and Cambro-silurian.

1867 (Dec.). Rev. John B. Perry, in a paper entitled: "Queries on the red sandstone of Vermont and its relations to the other rocks," read and published, in the *Proceed. Boston Soc. Nat. History*, December 18, 1867, Vol. XI, uses the name *Georgia slates*, with the same meaning that Mr. Marcou does, giving also the same list of fossils (see Separate, p. 9, 1868).

1880 (Nov.). Mr. Marcou publishes in his paper, "Sur les colonies dans les roches Taconiques des bords du lac Champlain (*Bulletin Soc. géol. France*, 3e série, tome IX, p. 18, Paris), a detailed description of Georgia, with sections in the text and on Plate II, and a geological map of all the area round Georgia, Parker's farm and St. Albans. He uses the name *Schistes de Georgia* and mentions two new fossils, a brachiopod and a *Dikelocephalus*.

1884 (Feb.). The *Bulletin American Museum of Natural History*, New York, Vol. I, No. 5, contains two articles: "Notice of some new species of primordial fossils, etc.," by R. P. Whitfield; and "Geological sections across New Hampshire and Vermont,"

by C. H. Hitchcock. In the first article Mr. Whitfield describes from the Georgia slates the fossils found there, as far back as 1861 and 1862, by Jules Marcou, under the names of *Orthisina orientalis* and *Dikelocephalus? Marcoui*. He gives also a better figure and description of *Olenellus Thompsoni* with the long caudal spine, from a specimen found by Marcou; and finally he adds a new trilobite *Angelina Hitchcocki*, also from Parker's quarry. He regards the Georgia slates and even the limestone at Pointe-Lévis as belonging to the typical Potsdam, without saying if it is the Potsdam sandstone of the village of Potsdam, or at Keeseville, or at any other locality in the state of New York.

Mr. Hitchcock describes several sections. His number "6. Clay slates and argilitic and other schists, supposed to be of Cambrian age. Of these, the *Georgia slates* of the Vermont report contain the *Olenellus* and *Angelina*, etc." At p. 158, he says, "It is just here that the fatal defect of the establishment of the Taconic system, as defined by Emmons, exists. His palaeontological arguments were better than the stratigraphical." Finally, Professor Hitchcock closes his article with some remarks on "Colonies," indorsing Logan's sections at Highgate Springs and Swanton, and the reality of his theory.

1885 (Jan.). "The Taconic system and its position in stratigraphical geology," by Jules Marcou, communicated December 10, 1884, to the American Academy (*Proceed. Amer. Acad. Arts and Sciences*, new series, Vol. XII, p. 174, Cambridge), contains a tabular view of the Taconic, p. 224, where the *Georgia slates* or *Olenellus zone* is placed in the middle of the Taconic. And at p. 231, another tabular view of the Eureka section by Mr. Walcott shows that the lower part of the *Prospect Mountain limestone* of Nevada is regarded by Marcou, as the equivalent of the Georgia slates or Olenellus zone. In this memoir Mr. Marcou gives the History—1837–1881—of the Taconic system and valuable letters of Dr. E. Emmons, Joachim Barrande and E. Billings, addressed to him, from 1860 to 1882, on that question.

1886 (Dec.). Mr. Walcott published his "Second contribution to the studies of the Cambrian faunas of North America (*Bulletin U. S. Geol. Survey*, No. 30, Washington), containing at pp. 15, 16, and 17, a Georgia section, taken on almost the same line as the one given by Mr. Marcou in 1880. He calls the strata "Middle Cambrian = Georgia formation or Olenellus," with a thickness of 4500 feet. The *Georgia slates*, No. 6 of the section, 200 feet, contains, besides the fossils already described, several new species, *Climacograptus? Emmonsi, Orthisina transversa* and *Microdiscus Parkeri;* and also several found before in other places, but not in this locality, before Mr. Walcott's researches at the Parker's quarry.

"The Georgia section is the most complete yet taken in Vermont," says Mr. Walcott, showing that Mr. Marcou's researches limited between Georgia, Phillipsburgh and Chazy, are amply justified as the most important region of the Taconic, north of the Taconic range. In beginning his studies of the Taconic system, at the same spot, twenty-four years after him, Mr. Walcott had a base, on which he was able to improve and correct errors, at the same time that he brought with him his experience and knowledge of the Taconic system of Nevada and the Great Cañon of the Colorado.

Paleontological remarks.— The paleontological part of Mr. Walcott's memoir under the title of: *Description of the Middle Cambrian fauna*, pp. 72–222, is excellent and of great value to the progress of the Taconic question. Apart from a few discrepancies in the synonymy of species, and priority of publications, both easy to correct, I shall call attention only to a few points.

1. *Atops trilineatus* is one of the first primordial fossils described, in 1844, by Dr. Emmons, as a new species and a new genus. Prof. James Hall identified it with *Calymene Beckii*, in 1847, suppressing at the same time the genus and the species. He was followed in his determination by Messrs. Fitch (1849) and Walcott (1879). In 1861, Barrande accepted the view of Emmons, recognizing characters special to the trilobites of the primordial fauna, and he opposed Hall's identification with *Calymene Beckii*.

Mr. Ford in 1871, 1873 and 1880 regarded this trilobite as a *Conocephalus* or *Conocephalites* or *Conocoryphe*, consequently as a true primordial fossil.

Finally, Mr. Walcott, retracting his first view of 1879, considers it as a *Ptychoparia*, a sort of synonym of *Conocephalites* and also a primordial genus. I may add, that Professor Walcott now thinks the fossil is not a *Ptychoparia* (*Conocephalites*).

I have always thought that Dr. Emmons was right in making it a new type having many affinities with the genus *Sao*, and I have, ever since 1860, used the fossil under the name of *Atops trilineatus* and as a characteristic primordial American fossil. From the primitive Taconic region of the vicinity of Troy and in Washington County, New York, it has also been found, first in 1867 at Swanton, Vermont, and afterward at Bic Harbor on the St. Lawrence opposite the Saguenaw river, Canada.

All the different generic names given after that of Emmons are very unfortunate and in direct violation of the law of priority. *Atops* is a good name which ought to be retained. The fossil is not a *Conocephalites*, and even if it were, *Atops* has priority over *Ptychoparia* by three years, for Corda did not create that genus until 1847, while Emmons' figure and description dated from 1844.

2. *Elliptocephala asaphoides*, another of the very few primordial fossils, first found and described by Emmons, is also a good species and a good genus. As I have said already, Prof. J. Hall made unnecessary new names *Barrandia* and *Olenellus* which created confusion without any apology for it; for the name *Paradoxides*, used by both Emmons and Barrande, was sufficient to characterize the fossil until a good and appropriate name could be chosen to replace *Elliptocephalus* if necessary.[1] *Ebenezeria* may be used now, in honor of the discoverer of the Taconic system; but, like Dr. Ebenezer Emmons, I think that it will be best and in accordance with priority to retain *Elliptocephalus*.

3. *Protypus Hitchcocki*, first referred by Mr. Whitfield to the genus *Angelina*, is made the foundation of a new genus by Mr. Walcott. That creation seems unnecessary, for the two fossils referred to *Protypus* belong to the genus *Ellipsocephalus*, Zenker, 1833, a Primordial trilobitic type of Bohemia, which those two fossils represent in the New World.

4. *Microdiscus quadricostatus*, published and established in 1855, is another good creation of Dr. Emmons, rightly referred by him to the Taconic system. The supposition, that it came from the Lorraine shales of Augusta county, Virginia, and is a *Trinucleus*, is, on the part of Professor Walcott, conjectural, and it may lead to curious confusion if accepted without very clear and unquestionable facts. It would have been strange if Dr. Emmons, always so successful in his classifications and paleontology of

[1] "The genus *Ellipsocephalus* was unknown to me at the time of the publication of *Elliptocephalus;* the name, from its similarity, is no doubt objectionable, but I am disposed to retain it for the present" (see Emmons' *American Geol.* Vol. I, Part II, p. 114, 1855).

the oldest palaeozoic rocks, had made a new genus from a specimen of a *Trinucleus;* a genus which, after all, is regarded by Messrs. Salter and Walcott as being a good one when applied to four other fossils, all of the American primordial fauna.

Graptolites zones of America.—Finally, Mr. Walcott, at p. 92, makes strictures on an extract of a letter of Emmons to Marcou, published in "Taconic system, etc." (*Proceed. Amer. Acad.*, Vol. XII, p. 188, Cambridge, 1885), in regard to the beautiful Taconic *Graptolites* referred by Mr. James Hall to the Lorraine shales (Hudson River group). Professor Walcott thinks that "Emmons had not a clear idea of the position of the shales of the Hudson valley that contains the *Graptolites* . . . nor of the shales at Pointe-Lévis carrying the graptolitic fauna." Farther on, he adds, "Professor Marcou refers the strata containing the Graptolites to the Taconic, and places it below the Potsdam sandstone, but I think without either stratigraphic or palaeontologic evidence." Mr. Marcou has given proofs of the Taconic age of the "Black slates" of Emmons at Swanton, Highgate, Phillipsburgh and Quebec, in publishing geological maps, sections and tabular views, repeatedly from 1861 to 1885.

The graptolitic question must be studied not in doors, but in the field, and all that I have seen in Vermont and at Quebec confirms and sustains the opinion expressed by Dr. Emmons.

The Director of the Canada Geological Survey, Mr. Selwyn, says: "Unfortunately in Canada geology, hitherto the stratigraphy has been made subordinate to mineralogy and palaeontology" (see *The stratigraphy of the Quebec group and the older crystalline rocks of Canada*, p. 14, 1879, Montreal), a remark, by the way, of which he made no use himself, and which is equally true for the whole Taconic area in the United States.

It is to be hoped that the paleontologists, who occupy themselves more especially with the studies of Graptolites, will conform to stratigraphy and not force the different zones of Graptolites all over the world, in America as well as in Europe, Asia and Australia, into the same horizon whether they belong there or not.

There are three zones of Graptolites in the Taconic system of eastern America. The oldest is in the St. John group and Georgia slates. The second horizon exists in the Pointe Lévis or Phillipsburgh group, where are the celebrated compound Graptolites, with many others. Then the third zone in the Swanton slates, near Swanton's bridge, and in the Quebec citadel slates at Quebec city and at the island of Orleans. Finally in the Utica and Lorraine shales, there is another graptolitic zone represented by only four or six species at most.

I do not enter into subdivisions of those four different great graptolitic zones, which according to localities can be divided in stages and even in beds; for only local descriptions and minute surveys can give those limited zonal details. But I give two tabular views which show at a glance the great divergence of opinions existing in regard to classifications and nomenclature.

Table A is taken from "C. Lapworth on Graptolites from Lower Palaeozoic rocks" (*Trans. Roy. Soc. Canada*, 4°, 1886, p. 183, Montreal).

I have reduced it to a smaller form, suppressing the names of the species of Graptolites and several names of localities in Canada and New York, but keeping carefully the divisions and classifications of Professor Lapworth.

TABLE A.

SHOWING THE VARIOUS HORIZONS, AND APPROXIMATE GEOLOGICAL AGE OF THE SEVERAL AMERICAN GRAPTOLITIC ZONES, BY CHARLES LAPWORTH, 1886.

Graptolitic Zones.	New York.	Canada.	Systems.
1st Zone.	Lorraine shales (Graptolites). Utica slates (Graptolites). . . .	No Lorraine shales. = Utica slates of Lake St. John and Ottawa. Pre-Utica? or shales of Citadel Hill, Quebec. (An horizon unknown in New York.)	Ordovician System.
2nd Zone.	Trenton and Black river, of Normanskill, near Albany. (Graptolites).	= Pointe Lévis or Trenton and Birdseye (shales of Marsouin river, etc.)	
3d Zone.	Chazy and Calciferous. . . . . (No Graptolites).	= Quebec group of Logan. Chazy or Levis. . . . . Calciferous or Levis and Quebec. Three different horizons.	Cambrian (upper) or Primordial System.

According to his view, the Quebec group of Logan is divided into an upper part, which he calls Lévis or *Phyllograptus* zone of St. Anne river; and a lower part, or Quebec and Lévis (probably of Calciferous age) with three subdivisions or horizons containing *Dictionema* and *Oldhamia*. The upper part is the equivalent of Chazy and belongs to the Ordovician or Cambro-silurian, or upper Cambrian of Sedgwick. The lower part —"probably of Calciferous age"— belongs to the Upper Cambrian of Lapworth (not Sedgwick).

The author recognizes the great difficulty of dividing the Quebec group into two parts, belonging to two different systems, and asks for a "careful study" in order to arrive at "the solution of the great geological enigma of the Quebec group and its puzzling associates." Professor Lapworth says: "The so-called Quebec rocks, of the town of Quebec, . . are not of Quebec age at all. . . They appear to be of greater antiquity than the Utica slates of Lake St. John." In his tabular view, he places them a little below the Utica, as "pre-Utica," above the Trenton, thus creating a group unknown in New York. He also says: "Thus it appears at present that we are destitute of any clear evidence that true Utica and Hudson river (or Lorraine shales) strata occur anywhere along the south side of the St. Lawrence from Gaspé to Quebec." A very important conclusion, differing widely from the classification used until now by the Geological Survey of Canada.

Table B shows four graptolitic zones instead of three, and unite together northeastern New York, western Vermont and the province of Quebec in Canada.

TABLE B.

SHOWING THE VARIOUS GRAPTOLITIC ZONES, GEOLOGICAL AGE AND CLASSIFICATION FOR THE NORTHEASTERN PART OF NORTH AMERICA, BY JULES MARCOU, 1887.

Graptolitic Zones.	New York, Vermont and Canada.	Systems.
1st Zone.	Lorraine shales (Graptolites in New York). No Lorraine shales in Vermont and Canada. Utica slates (Graptolites in New York, Vermont and Canada).	Cambrian or Champlain System.
	Trenton limestone Black river } No Graptolites in New York, Vermont and Canada. Birdseye	
	Chazy limestone Calciferons sandstone } No Graptolites in New York, Vermont and Canada.	
	Potsdam sandstone. No Graptolites.	
2nd Zone.	Swanton slates or shales of Citadel Hill, Quebec (Graptolites in Canada, Vermont and New York).	Taconic System.
3d Zone.	Pointe-Lévis or Phillipsburgh formation (compound Graptolites at Lévis and St. Anne river, Canada).	
4th Zone.	Georgia formation St. John formation } Middle Taconic (Graptolites at Georgia, and near St. John, New Brunswick.)	

The fourth zone of Graptolites is older than any of the zones of Professor Lapworth; and although containing only three species, found at Parker's quarry (Georgia) and at Porter's Brook, St. Martin, near St. John (New Brunswick), is most important, for it shows, without a possible doubt, that the Graptolites made their appearance in America sooner than in Europe (England, Scandinavia and Bohemia).

There is a great gap between the second and first graptolitic zones, during the deposit of the Potsdam, Calciferous, Chazy, Birdseye, Black river and Trenton. In America the Graptolites belong mainly to the Middle and Upper Taconic, or primordial and supra-primordial faunas.

VI. The Entomophthoreae of the United States.

By Roland Thaxter.

THE material upon which the following account is based was accumulated, for the most part, during the seasons of 1886–7, from several localities in New England and in North Carolina, which were examined with such thoroughness as the limited time at my disposal would allow. The New England material was chiefly collected at Kittery Point, Maine, the southernmost point in the state, and in the vicinity of Boston; while the remainder is the result of two weeks botanizing in the alpine and sub-alpine region of Mt. Washington, N. H. The more southern forms represent three principal localities in or near the western portion of North Carolina. Of these Cullowhee, 2400 ft. above the sea, is the southernmost, having a flora of a distinctly southern type; while the two others, Cranberry (3250 ft.) and Barbank (E. Tennessee, 3500 ft.), have a climate and flora not unlike that of the southern New England states. The eastern section of the United States is thus fairly well represented in so far as the localities which have been studied are concerned; yet it is scarcely necessary to remark that the forms obtained during a few weeks' sojourn in each locality, in the course of general botanizing, can represent only in a fragmentary way the Entomophthoreae of this section of the country. The forms occurring in the more remote regions of North America are, moreover, as yet almost wholly unknown; and, although my observations have served to increase the number of American representatives from four previously recorded forms to the considerable number hereafter enumerated, it cannot be supposed that the record is other than very imperfect. The present paper is therefore complete only in so far as I have endeavored to combine my own observations with those of previous students of the group in this country and in Europe.

For this purpose the literature of the subject has been consulted as far as has been practicable, and a list of the papers that I have myself seen is appended to this memoir. It should be understood, however, that this list is not intended as a complete record of all that has been written upon the subject, and is merely given for convenience of reference in the text.

The Russian publications of Sorokin were kindly procured for me in St. Petersburg by Mr. Charles Eliot, and for some knowledge of their contents I am indebted to Mr. Ivan Panin. For the privilege of examining the remaining papers, not contained in the University libraries in Cambridge, together with other invaluable assistance, I am indebted to Professor Farlow, in whose laboratory the microscopic work upon my paper has been for the most part done. To Miss Hapgood I owe certain extracts from the Polish of

Nowakowski, and I am also indebted to Professor Farlow, Messrs. C. V. Riley, L. O. Howard, Henry Edwards and A. F. Chatfield for several interesting specimens. To Mr. C. W. Woodworth and Prof. S. W. Williston I also owe certain entomological determinations.

The plants that are to be considered in the present paper belong to a class which, although made up of several groups differing widely from one another in their habit and affinities, is yet, by reason of a peculiarity common to all its members, possessed of a certain individuality of its own that renders it susceptible of a consideration apart from all other forms of plant life. This peculiarity, by reason of which the class is usually characterized as entomogenous or entomophytous, consists in an obligatory parasitism upon insects, which, although in some instances it exists without apparent injury to the insect host, is usually of such a nature as to cause its death; often resulting, especially among noxious insects, in widespread mortality.

Although a few of the more common or conspicuous forms of entomophytous plants had attracted the notice of botanists even in the last century, it was not until within comparatively recent years that they began to be studied with any care, and the work of Robin[1] is the first contribution of importance on the subject. This work still remains, with two exceptions,[2] the only attempt that has been made to bring together all the known forms of insect parasites; but since its publication very important contributions have been made to our knowledge of the subject, through the medium of numerous scattered papers.

My attention was first turned in this direction in the course of entomological studies on the life-histories of certain insects; in the course of which I was often greatly annoyed by losing large numbers of larvae and pupae through the agency of fungi. Having by this means and from other sources accumulated a certain amount of material, it was my first intention to include in my paper all the entomogenous plants recorded from America; yet, owing to the many difficulties presented by the ascomycetous forms, involving a careful study and comparison of more abundant material than I could command, as well as by reason of the considerable additions to our Entomophthoreae resulting from my observations, I have decided to confine myself for the present to the members of this family, trusting to a future opportunity of extending my paper in conformity with my original plan. In the meantime a brief summary of the more important groups may not be out of place in this connection, and will be a fitting introduction to the more detailed consideration of the Entomophthoreae which follows.

Summary of entomogenous plants.—Although the spiders and myriapods are not exempt from the attack of peculiar vegetable parasites, the hexapod insects offer by far the greater number of instances of this nature. Among the seven orders of the latter class usually enumerated, the Neuroptera and Orthoptera are almost wholly free from such attack; and, until recently, the first named order was considered wholly exempt in this respect. Of the remaining orders the Lepidoptera and Diptera are apparently the greatest sufferers; while the Hemiptera, Coleoptera and Hymenoptera are about equally af-

[1] C. Robin, *l. c.*

[2] Sorokin, *l. c.*, C, and Gray, G. R: Notices of insects that are known to form the bases of fungoid parasites, London, 1858.

fected. Of the different stages of insects the imagines, larvae and pupae may all be parasitized, and in some instances a single parasite may attack all these stages in one or more species of the same or different orders; while in others it may confine itself to a single stage or species.

Entomogenous plants may in a general way be referred to five principal groups: one including the bacterial forms which produce disease in insects; a second represented by certain entophytous algae; and three others all belonging to the fungi proper.

The first mentioned group, represented by the Bacteria, is chiefly of interest from an economic, rather than from a botanical point of view, as the supposed cause of destructive epidemics among useful as well as noxious insects. Instances of this kind are presented by the disease known as *flacherie* so destructive to silk worms, and in affections of a similar nature in other insects, where the "active principle" has, in some cases, been traced to bacterial forms which have been considered sufficiently peculiar to receive distinctive names. The systematic study of the group is necessarily one of great difficulty, and any opinion as to the validity of specific distinctions in such cases can only be formed by specialists in this department; but from a practical standpoint the existence of such affections promises to afford an important means of defence against noxious insects.

The second group includes a small number of peculiar filamentous algae, represented by *Enterobryus* and its allies, that live attached to the digestive tracts of certain myriapods and coleopterous larvae. They are apparently nearly related to *Oscillaria* or *Beggiatoa* among the Protophytes; but, owing to insufficient observations upon them, their exact affinities are unknown. Their habit is probably one of commensalism, rather than of true parasitism; the partially digested food of the host being absorbed directly from the digestive tract.[1]

The fungoid parasites of insects are, as before mentioned, represented by three chief groups: the Entomophthoreae, the Laboulbeniaceae and the entomogenous forms which constitute the bulk of the genus *Cordyceps*. Since the first of these is to receive special consideration hereafter, it need only be said that its members are closely allied to the Mucorini among the Zygomycetes, and are entomogenous with few exceptions.

The *Laboulbeniaceae* constitute a small group of very peculiar and minute forms which have been placed by DeBary among the doubtful Ascomycetes. Their parasitism is an external one, which apparently results in little if any inconvenience to the host; each individual being fixed by a pedicellate attachment to the legs, thorax or other portion of the affected insect. Several genera on Diptera, Coleoptera, etc., are described by Peyritsch[2] to whom we are principally indebted for our knowledge of the group, although the first genus of the family (*Laboulbenia*) was described and figured by Robin.[3] The single American representative thus far recorded has been described by Professor Peck as *Appendicularia entomophila*, n.g. et sp.[4]

The pyrenomycetous genus *Cordyceps* affords by far the most conspicuous examples of entomogenous plants, many of which are of large size, or brightly colored, and have

[1] See Leidy, Smiths. Contr. to Knowledge, v, pp. 1–67 (1853) and Robin *l. c.*, p. 395.

[2] Sitz. d. Akad. wiss. Wien., 64, i, p. 441 (1871): 68, i, p. 227 (1873): 72, i, p. 377 (1875), plates.

[3] *l. c.*, p. 622, plates.

[4] Peck, 38th Report, p. 95, with plate.

therefore received more attention from earlier botanists. Their imperfect or "*Isaria*" condition is familiar to all entomologists as a pest in breeding cages and puparia; although the ascigerous condition is usually of rare occurrence. They attack all orders of hexapod insects, larvae and pupae as well as imagines, and also certain spiders; often producing what is vulgarly known as a "vegetable sprout" several inches in length. A considerable number of American species are recorded; yet, owing to the lack of sufficiently well-marked microscopic characters, as well as to the scarcity of good material for study, the group presents many difficulties, as is usual in cases when too great reliance has been placed upon gross characters as a means of specific distinction.

In addition to the groups above mentioned there are several other isolated instances of entomogenous fungi, among which should be mentioned the so-called *Botrytis Bassiana* which produces the disease known as *Muscardine*, so destructive to silk worms in Europe and apparently identical with a similar form occurring in this country.

Facultative parasites of insects.—In addition to the obligate parasites briefly enumerated above, insects are often subject to the attack of numerous small moulds and bacteria which are in no sense peculiar to them, although they may temporarily assume a habit which is practically that of a true parasite, entering the living host and causing its death. It seems also probable that one or two forms which are truly entomogenous are yet saprophytes, as in the case of a certain *Cordyceps* (*C. armeniaca*) presumably growing upon the remains of insects in the excrement of insectivorous birds, as well as the members of the genus *Basidiobolus* hereafter mentioned, which occur upon the excrement of frogs and lizards. DeBary has also pointed out that the species of *Cordyceps* are normally partial saprophytes, since they attain their full development after the death of the host; but whether wholly parasites or saprophytes, or parasites and saprophytes combined, their peculiarity in growing naturally only upon insects or insect remains constitutes them entomogenous, in the sense in which I use the term, to the exclusion of such forms as *Penicillium*, *Aspergillus*, *Cladosporium* and the like; which, although they may at times not only grow on insects, but become temporarily truly parasitic upon them, are yet found in nature on a great variety of other substances.

With this brief reference to entomogenous plants in general we may now turn to the consideration in detail of the group which forms the subject of the present paper.

Entomophthoreae.

General characters.—This family at present comprises several genera, the members of which are not all entomogenous, though closely related structurally. They are distinguished by the production of numerous hyphae of large diameter and fatty contents, which, in the insect forms, ultimately emerge from the host in white masses of characteristic appearance and produce at their extremities large conidial spores which are violently discharged into the air and propagate the disease. The common house-fly fungus is perhaps the most familiar example of the kind, and no one can have failed to notice the affected flies in autumn or late summer adhering to looking-glasses or window-panes surrounded by a smoky halo of discharged conidia. In addition to these conidia the propagation of the fungus, after long periods of rest, may be provided for by the forma-

tion of thick-walled resting spores adapted to withstand successfully the most unfavorable conditions. These resting spores, which may be either sexual (zygospores), or asexual (azygospores), finally germinate and produce conidia that are discharged in the usual fashion and serve to infect fresh hosts. Such in brief is the general mode of development in Entomophthoreae; yet it is subject to so many variations and modifications in the different genera and species that a detailed comparison of them is instructive as well as necessary for a sufficient understanding of the family. I shall therefore consider each stage among the *Empusae* in some detail, having first briefly mentioned the more important points of structure in the remaining genera. These genera are four in number: *Completoria*, *Conidiobolus*, *Basidiobolus* and *Massospora*, the members of which, as already mentioned, are not all entomogenous.

The genus Completoria, which, as has been pointed out by Nowakowski and others, should be placed among the Entomophthoreae, was discovered by Lohde (*l. c.*) in the prothalli of ferns and has been subsequently more thoroughly investigated by Leitgeb (*l. c.*). Its presence is indicated by brown spots upon the prothallus within the cells of which it exists in the form of short thick hyphae, which spread from cell to cell by means of slender projections. The latter penetrate the cell wall, which becomes modified around them into a sheath-like structure, and having thus gained access to an adjoining cell continue their development at its expense. The two usual forms of reproduction, by means of conidia and resting spores, are found in the genus and are of a very simple type. When about to produce conidia the short thick hyphae or *hyphal bodies*, as they may be termed for convenience, germinate sending up asexually fructifying hyphae or *conidiophores* which, after penetrating to the surface of the prothallus, become swollen at their extremities and produce ovoid conidia which are discharged into the air. After their discharge the conidia become pear-shaped, and the basal papilla of attachment to the *basidium*, or swollen extremity of the conidiophore, is protruded as a hyaline appendage (*Nabel*). The conidia germinate and spread the disease by entering other prothalli with which they may come in contact. The resting spores are formed within the cells of the prothallus, and result from the mere contraction of the contents of the hyphal bodies, which become surrounded by a thick wall. According to Leitgeb, this formation shows no indications whatever of a sexual origin, although his figures do not seem to preclude such a possibility in view of what is at present known of sexual processes in the group. The germination and further development of these resting spores have not as yet been observed. The genus is at present represented by a single species, *Completoria complens* Lohde, and has been found and cultivated by Leitgeb upon prothalli of numerous genera and species. It is at present unknown in this country. From this comparatively simple form we may now pass to the consideration of one somewhat more complicated, which is also parasitic upon another plant, in this instance a thallophyte.

The genus Conidiobolus was accidentally discovered by Brefeld in connection with his researches upon the Tremellini on which it is parasitic; and its discoverer, having obtained spores from cultures in which it had appeared, was enabled by cultivating them in nutritive solutions, to trace its development with the greatest completeness. The conidia grow readily in a decoction of horse dung, forming a mass of branched and rarely septate hyphae; which, having nearly exhausted the nutritive solution, become

broken up, through the formation of partition walls, into numerous irregularly lobulated fragments which correspond to hyphal bodies, as I use the term. These lobules appear early in the development of the hyphae, in the form of irregularly swollen projections from them; and mark the points of origin, even at an early stage, whence the conidiophores are subsequently to arise. Shortly after this general disintegration of the hyphae, single, simple conidiophores arise from each fragment, in number corresponding to the swellings above described, and produce large, ovoid conidia which are discharged in the usual way. The chief interest of the genus lies, however, in the formation of its resting spores, which seem to be of sexual origin. This formation of zygospores appears as that of the conidia begins to disappear, so that both forms are at first developed side by side, while eventually the conidial formation ceases entirely,— a circumstance which seems to verify this author's previously expressed opinion that an alternation of some regularity exists between the appearance of the two types of reproduction. In the formation of these zygospores, hyphae arise from swollen projections, similar to those already described as being the origin of the conidiophores, which, after a variable develment, conjugate through the apposition of their swollen extremities, the contents of one extremity uniting with that of its fellow through the absorption of the intervening walls, and producing in one of them a thick-walled zygospore. Owing to a difference in size of these conjugating extremities, Brefeld was inclined to place the family among the Oomycetes; but the previous observations of Nowakowski[1] in *Empusa*, together with more recent studies of the family, render this improbable. In from ten days to five weeks after their formation, the resting spores were made to germinate; and sending out one or more hyphae produced usually a single conidium resembling those characteristic of the species. Of these, two are described: *Conidiobolus utriculosus* and *C. minor*, neither of which has been observed in the United States.

The genus Basidiobolus, discovered by Eidam, is perhaps the most interesting of the Entomophthoreae from the unusual differentiations which accompany its asexual as well as sexual reproduction. Unlike other members of the group the species are wholly saprophytic, occurring naturally upon the dung of frogs and lizards after evacuation; while they may be readily cultivated in nutrient solutions similar to those employed by Brefeld in his study of *Conidiobolus*. According to Eidam, the fungus is present in the digestive tract, only in the form of spores or hyphal bodies which are dormant until they are evacuated with the faeces upon which they subsequently develop, forming large colorless hyphae with numerous cross partitions. These hyphae do not become broken up into hyphal bodies before reproduction commences, except in so far as this condition may be approached in cases similar to that figured by Eidam[2] where, in a concentrated nutrient solution, the segments of the hyphae become rounded; but do not, however, break apart as in *Conidiobolus*. In reproduction the hyphal segments may produce slender single conidiophores which, rising vertically, become greatly swollen at their extremities. From the apex of this conidiophore the large conidium buds and, during its formation, the swollen extremity which bears it becomes modified by the contraction and thickening of its walls into a peculiar piece or *basidium*, which is discharged, together with the conidium, by the explosion of the slender conidiophore.

[1] *l. c.*, A. [2] *l. c.*, Pl. IX, fig. 10.

The formation of zygospores is also quite peculiar, and always results from the conjugation of two adjacent cells in *the same* hypha, except in some instances where two conidia may conjugate directly. In either case conjugation is preceded by the formation of finger-like processes from either of the conjugating cells, which, arising opposite each other, are usually closely applied. Conjugation, however, does not take place by means of these processes which, at first sight, would suggest a *Rhynchonema*-like type; but by the absorption of the partition wall between the conjugating cells and the direct passage of the contents of one into the other. In this instance, as well as in *Conidiobolus*, the cell in which the zygospore is to be formed is recognizable before conjugation by its larger size. The function of the finger-like processes above mentioned seems wholly connected with the division of the nuclei which pass into them and become divided in two parts; the upper portion disappearing without becoming a new nucleus while the lower passes as a nucleus into the zygospore. The zygospores are of two varieties: one, larger than the more common form, is very thick walled and covered by a peculiar brown incrustation which renders it opaque; the smaller and more usual variety was made to germinate in nutrient solutions and produced hyphae which developed the characteristic conidia of the species.

Two genera remain to be mentioned: *Tarichium* of Cohn and *Massospora* Peck. The former, as has been several times pointed out by writers on Entomophthoreae, is, without doubt, merely the resting stage of some *Empusa*, the conidia of which are as yet unknown. In *Massospora*, however, which has not, I believe, been previously referred to the present family, we have a form quite peculiar, the near affinities of which cannot be determined by reason of the absence of any knowledge concerning the formation of its resting spores, or the germination of the multitudinous internal spores which characterize the genus.

With this brief mention of the remaining genera we may now pass to a consideration of the genus *Empusa*, which, with its subdivisions, includes only entomogenous forms. I have preferred to consider these subdivisions as a whole under *Empusa* as a matter of convenience, as well as from the fact that I am not at present inclined to believe that they have more than a subgeneric value; but my reasons for this course, as well as for my use of the name *Empusa* in preference to *Entomophthora*, may be better given hereafter when the principal morphological differences in the species have been touched upon.

The Genus Empusa.

Infection and production of hyphal bodies.—As has already been mentioned, infection among entomogenous Entomophthoreae results from contact with a conidial spore which, adhering to the insect host, enters its body by means of a hypha of germination. The exact method of this entrance is hardly a subject for actual observation unless, perhaps, in insects which, like many aphides, are semitransparent, and, owing to their soft integument, afford an easy entrance to the hypha at almost any portion of the body. In other insects, more especially beetles, grasshoppers, ichneumons and the like, the horny integument must diminish considerably the chances of infection; and in such cases the stigmata or the thin membrane connecting the body segments and leg joints must be the

principal points of entrance. Infection, resulting from the ingestion of spores with the food, does not, I think, occur as is indicated by experiments with wood crickets which will be mentioned under *E. Grylli;* and, as a rule, the digestive tract during life does not seem to be penetrated by the fungus.

After the hypha of germination has entered the body of the host, it develops with some rapidity at the expense of the softer tissues. This growth usually differs from that described in *Conidiobolus* from the fact that, instead of producing a branched mycelium, the hyphae multiply, not by branching and continuous growth, but by the formation of what I have previously called hyphal bodies, which consist of short, thick fragments, of very varied size and shape, that are continually reproduced by budding or division until the insect is more or less completely filled with them. In some instances these hyphal bodies have been observed as naked masses of protoplasm with an amoeboid movement, as is stated to be the case in *E. colorata;* but in most instances a cell wall may be demonstrated. In *E. Grylli*, at an early stage, the hyphal bodies may be seen loosely adhering in clusters as a result of continued budding; but more often in this and other species they occur singly or in pairs. It is probable, however, that this mode of development is subject to considerable variation and that in some instances a mycelium may be produced directly, after the entrance of the germinating hypha. I have been unsuccessful in endeavoring to cultivate conidia in sterilized solutions; although, by employing a drop of water in which numerous aphides had been crushed, I was enabled to obtain a fairly vigorous growth from the conidia of *E. aphidis*. In this case the germinating hypha branched in all directions, forming a considerable mycelium with numerous septa; but, owing to the lack of nutriment as well as to the presence of bacteria, the hyphae soon became much attenuated and finally died. DeBary[1] states that this production of a mycelium as a first result of infection occurs in *E. orispora*, *E. curvispora* and *E. sphaerosperma* (*radicans*); but, according to Nowakowski, in his summary of the Empusae, the first two are not thus characterized, while my own observations of *E. sphaerosperma* do not bear out his statement that the "fungus growth" within the host is filamentous in all cases. It seems not improbable that both forms of development may occur under different conditions; but, however this may be, the termination of the first or merely vegetative condition of the fungus consists in the production of a mass of hyphal bodies which fill the host more or less completely; and in no instance, I believe, is this stage or its equivalent omitted by the direct growth of the original hyphae into conidiophores. On this assumption, in cases where a direct mycelial growth follows the entrance of the hypha of germination, if indeed such instances occur, this mycelium must fall to pieces into hyphal bodies, before the commencement of growth the direct object of which is reproduction, in a fashion resembling that above described at a similar stage in *Conidiobolus*.

The hyphal bodies, the production of which usually marks the end of any appropriation of nourishment from the host and generally occurs at about the time when the host has ceased to live, are in many cases somewhat different from those which have previously characterized the fungus and often possess great regularity, both in size and shape, closely resembling spores. In *E. Fresenii*, for example, the original hyphal bodies

[1] Vergl. Morphol. d. Pilze, etc. [2] *l. c.*, B, p. 176.

are such as are represented in figs. 106–108, while fig. 127 shows examples of those which precede the spore formation and are derived from them. In other cases, the ultimate hyphal bodies may be very irregular in size and shape. In all instances, they contain a highly concentrated fatty protoplasm and are capable of subsequent and often very extended development.

Having reached this condition by the production of a mass of hyphal bodies, the fungus, under favorable conditions of temperature and moisture, may proceed at once to the completion of its development; but if these conditions are absent, a resting or chlamydosporic condition supervenes, in which the contents of each hyphal body become surrounded by a single wall of variable thickness according to the duration of this enforced resting stage. In this manner, the fungus may remain dormant for a considerable period until the presentation of proper conditions for further growth. How long the chlamydospores may live, I am unable to say; but I have observed their germination after several weeks, and they probably retain their vitality for a much longer period, and may perhaps hibernate under certain circumstances. They form a very convenient means for the cultivation of Empusae in water, in which they proceed at once to the formation of conidia or of resting spores. The period from first infection to the formation of chlamydospores or hyphal bodies, prior to the commencement of the reproductive growth, varies according to the host. In very minute and ephemeral insects, such as many gnats that are commonly attacked, the period must necessarily be short, not exceeding two or three days; but in cases where I have been enabled to observe this period, which has been unfortunately only in connection with the larger hosts, such as flies and caterpillars, it varies from six to twelve days.

Germination of the hyphal bodies and chlamydospores.—Having appropriated the whole or the greater portion of the nourishment afforded by the host, the fungus is now ready to expend it in the second or reproductive stage of its growth. Under the influence of a moist atmosphere and a sufficiently high temperature, the hyphal bodies "germinate" with great rapidity. The amount of moisture needed to produce this germination is variable in different forms. In the common house-fly fungus (*E. muscae*), for instance, a slight change in the amount of atmospheric moisture is sufficient to produce conidial formation and discharge. This is very noticeable on the seashore, where slight changes of the wind on or off the water produce a very rapid and noticeable effect upon flies thus parasitized when observed in the ordinary atmosphere of the house. In other instances, more especially in those species which, unlike the house-fly fungus, are characterized in their conidial reproduction by a considerable external growth of hyphae, a much greater degree of moisture is a necessity. Extreme cases of this kind are found in species such as *E. conica* or *E. sepulchralis* which occur only in very moist situations.

In germinating, each hyphal body or chlamydospore sends out one or more hyphae which grow with great rapidity; but the manner of this germination, together with the subsequent development of the resulting hyphae, varies considerably in different species and under different condition. In the simplest case a single hypha thus produced may grow directly to the outer air and then produce a single conidium or set of conidia, according to the type peculiar to its conidiophores. In other cases, a single primary hypha may

branch indefinitely, each ultimate branch becoming a conidiophore similar to those of the more simple case just mentioned. This usually occurs where the conditions of growth have been very favorable and may be found side by side with the more simple form.

Although the number of germinating hyphae developed from a single hyphal body is usually small, not as a rule exceeding one or two, certain instances occur in which the number is considerable. In *E. conglomerata*, for example, as described by Sorokin, long hyphal bodies are found which germinate in all directions and are not unlike, in this respect, the hyphal bodies previously mentioned in *Conidiobolus*. These hyphae subsequently branch and anastomose, forming a coherent mass which Sorokin has termed a *stroma*, and on which he has based a classification of *Empusae* into "Stromaticae" and "Astromaticae." It is probable, however, that this condition is interchangeable with the more ordinary form, since in some specimens for instance of *E. apiculatus*, I have found well marked stromata, while in others the direct development of the conidiophores from hyphal bodies has been distinctly traceable.

The most singular modification of this kind, however, occurs in *E. aphidis* and *virescens* which are the only species thus far in which it has come under my observation. Here we have a body which appears to be of the same nature as the hyphal bodies in other species, of regular spherical form and with a highly refractive fatty contents, from which, soon after the death of the host, hyphae begin to germinate in all directions and in incredible numbers, in a fashion that reminds one of a head of *Aspergillus* (figs. 239 and 261). The hyphae thus produced then branch and divide, becoming separated into a mass of irregular, short, contorted hyphae which fill the host and distend its body. This breaking to pieces of hyphae produced from hyphal bodies also is found in species where the usual type of germination occurs: as in *E. muscae*, in which, just before the emergence of the conidiophores, the body cavity contains a mass of irregular short hyphae together with germinating hyphal bodies.

Formation of conidiophores.—The germination of the hyphal bodies results either in the production of sexual or asexual resting spores (zygo- or azygospores); or of conidiophores bearing *conidia*. In the latter instance hyphae, arising directly or indirectly from the hyphal bodies, grow rapidly outwards, burst through the less resistent portions of the host's integument in spongy masses, in most instances of a livid white color. These masses sometimes vary to pale or bright green or dull olive, even in forms where their normal color is white; and there is considerable variation in their general appearance according to the species or to the conditions of their development. In some cases, they barely project beyond the body of the host and are confined to the points of emergence which are generally afforded by the thin intersegmental membranes through which they project in cushion-like rings as in *E. muscae*. In other cases, the external growth may be more extended and the masses may coalesce so as to cover the whole body with a continuous layer of conidiophores which may form a mass several times as large as the insect from which it springs.

In the first and more simple case, where there is little external fungus growth, the cushion-like masses are usually formed by *simple* conidiophores (fig. 1) which, although each may be derived in common with many others from the same hyphal body, are yet ultimately simple, producing few or no branches outside the host's body and giving rise

to a single conidium. In the second instance, where the external growth is greater, a different type usually occurs in the conidiophores. Not only is the external branching very considerable, but the ultimate divisions of each conidiophore are arranged in a corymbose or digitate fashion, as in figs. 202 and 220. This occurrence of simple and compound conidiophores in different species has led to the generic separation of the two groups; yet the distinction is by no means absolute, and intermediate forms occur, as in *E. culicis*, *E. apiculatus* and a few additional species. The converse is also true, and simple conidiophores are very commonly found in species where the type is usually compound. As has been already remarked, the growth of conidiophores is very rapid under favorable conditions; and an insect containing hyphal bodies, if placed in a damp, warm atmosphere, may give rise to the characteristic white masses in a few hours. Soon after the appearance of these masses the production of conidia commences, and this brings us to the next step in the conidial development.

Formation and discharge of the conidia.—The terminal portion of the conidiophore, whether this be simple or one of several digitations, is termed the *basidium* and is usually swollen to a greater or less extent. From the apex of this basidium, which is homologous with similar structures occurring among the Mucorini, the conidium, or more properly the mother cell of the conidium, is formed by budding. This bud increases at the expense of a portion of the contents of the basidium, until it has attained very nearly the normal shape and dimensions of the conidium; when it becomes separated from the basidium by a cross partition, which forms at first a horizontal plane of separation between the two and is homologous with the *columella* of the Mucors. Within the mother cell thus formed is developed a single conidial spore, the walls of which are normally in close apposition to those of its containing cell, which must thus be considered a sporangium reduced to its simplest terms and modified to combine economy of material with a judicious dissemination. The resemblance to a one-spored sporangium is clearly seen in cases where, through the absorption of water by osmosis, the wall of the mother cell becomes separated from that of the conidium; a phenomenon which is very commonly seen after, or even before, the discharge of the conidium, and is sometimes carried to such an extent that the conidium may be seen floating free in a large spherical mother cell (fig. 321).

When the conidium is fully developed, and even previous to this, the contents of the spore, as well as of the basidium, begin to expand through the absorption of water. At first, as a rule, the contents of the basidium exert the greater of the two forces thus produced; perhaps owing to the fact that a more rapid absorption of water is possible through its single wall than through the double wall of the conidium. For this reason, the columella is at first forced outwards into the conidium towards which its convexity is thus turned. In some instances, especially in cases where the basidia are large and strong, this condition of things may continue until the discharge of the conidium. Such is apparently the explanation of the appearance figured by Nowakowski[1] which is referred to by Eidam[2] as a mechanism for discharge, very different from that usually found in Empusae. I think, however, that this will prove to be only an extreme case of the nature just described. In my own experience I have observed this appearance only

[1] *l. c.* **B**, Pl. xi, fig. 82, etc. [2] *l. c.*, p. 186.

infrequently in the species referred to, *E. Grylli*, and in allied forms (fig. 83). It should be noted that contraction of the spore contents from any cause might also produce the same condition. In by far the majority of cases, the contents of the conidium, being more dense than that of the basidium, finally exert a greater pressure and forces the columella back into the basidium, thus reversing its former position. The sum of these opposing forces is very considerable, and as a natural result of their action a rupture of the wall ensues at the point where they are opposed, that is, in a circle round the base of the mother cell. This circle of rupture is usually very evident in discharged conidia, being indicated by a slightly ragged projection which forms a ring at the base of the papilla (fig. 85). As a result of this rupture, the conidium is discharged violently into the air, often to a considerable distance. The columella commonly remains unbroken by this discharge, although it is often greatly stretched and hangs from the basidium as a tongue-like projection. In other instances it may be accidentally broken or this rupture may be normally connected with the discharge. In the latter case, a portion of the protoplasm from the basidium is discharged with the spore and serves to fix it to any object with which it may come in contact.

The presence or absence of a columella in different species has been made a point of structural difference to which more weight has, I think, been given than is justified by the facts. The assumption that a columella exists and is wholly or partially destroyed by the discharge of protoplasm above alluded to, in cases like *E. muscae* for example, seems to me at least as warrantable as the apparently needless assumption of the absence of so characteristic a structure. Moreover, the presence of a ruptured columella is often indicated even in *E. muscae* by the numerous shreds that may be seen adhering to the basidium after discharge (fig. 2).

The conidia and their germination.—The conidia in their normal condition are of various size and form, often varying considerably in the same species. The extremes of shape are well represented by the nearly spherical spores of *E. muscae* and the slender tapering form of *E. gracilis*. In size they vary from about 10 μ in length to 75 μ or over. They are usually hyaline, rarely slightly colored, with a fine granular contents; or, more commonly, contain coarsely granular protoplasm with large fat globules. In many instances, these fatty bodies are so regular in size and shape that the conidia resemble asci filled with spores; a fact which probably accounts for the statement "Flocci fertiles intus sporidiis globosis referti" in a description of what seems undoubtedly an *Empusa*, by Fries.[1] The common occurrence, also, of very large single oil globules seems to have caused a similar error. The walls of the conidium are, so far as known, always smooth, without spines or similar modifications, and possess an adhesive quality which serves to attach them readily to any object, even when their discharge is unaccompanied by the mass of protoplasm above described. The basal portion of the spore is always more or less papillate, the papilla being in reality that portion of the spore proper which projects from within the mother cell, from which it is distinguished by the ring of dehiscence.

The conidium when discharged, if by chance it has come in contact with a suitable host, adheres to it, and sends out a hypha of germination which enters its body as previously described. When placed in water the conidia give rise to one or more hyphae

[1] *l. c.*

which branch and elongate, growing constantly more attenuated, their protoplasmic contents becoming separated by successive cross partitions from the empty hyphae left behind (fig. 240). It may here be mentioned that this separation by cross partitions is common in the general growth of the fungus. The hyphae produced thus from conidia have the usual characteristics: a granular protoplasmic contents which often shows a very noticeable streaming motion, and contains large oil globules and a hyaline wall. The power of germination lasts, according to Brefeld, at most only a week, or slightly more in *E. radicans* (*E. sphaerosperma*); but in my own experience I have found the period usually much shorter than this. The period is in all probability very variable; spores that have been formed under unfavorable conditions being better able to withstand similar conditions: the endurance of the spores, moreover, varies with different species. As a rule, germination takes place very soon after discharge, and if the conidium has neither fallen upon a proper host nor upon a wet surface it proceeds to form

Secondary conidia.—The secondary conidium is a provision for further dissemination in case the primary spore has fallen on a substance unsuited to its proper development. The most common method of formation consists in the production of a hypha of variable length, which, growing vertically upwards, becomes swollen at its extremity into a basidium, and produces a conidium similar to that whence it is derived. This is discharged in the usual fashion, and may in turn produce tertiary, etc., conidia, in a similar way, until its vitality is exhausted or it has found a suitable lodgment. The conidiophore formed in this process is usually simple, even if the type from which it was derived is digitate; yet I have seen, in a case where numerous spores had been discharged upon wet moss, that the hyphae arising from them united to form a mass of conidiophores of the digitate type peculiar to the species.

Although the form of secondary conidium just described is most commonly found, and is apparently the normal type in all species under favorable conditions, it is subject to several interesting variations that are dependent, for the most part, upon an insufficient supply of moisture. The first of these consists in the production of a secondary conidium quite different from the primary, either by direct budding from it (fig. 9), or borne upon a short hypha of germination (fig. 362). These conidia are also discharged; but are apparently better suited to resist unfavorable conditions than the ordinary ones, and probably retain their power of germination much longer. The most singular modification, however, is presented by a few species allied to *E. sphaerosperma* and *E. Fresenii*. In these forms and their allies, when the conditions of moisture are unfavorable for the ordinary process, a long, slender, capillary conidiophore is produced, on the end of which is borne a peculiar secondary conidium differing still more widely from the parent spore than in the case just mentioned.

These secondary conidia (figs. 157, 191, etc.) are, with one exception, nearly almond-shaped, with noticeably thick walls, and are not discharged. Whether they ever produce tertiary spores similar to the primary ones, I have been unable to determine; but the formation from them of tertiary conidia similar to themselves is not uncommon. They may often be seen germinating by means of an irregular hypha which, beginning as a drop-like protuberance from the apex of the spore (fig. 119), may grow to a considerable length (fig. 122). Eidam, in his paper on *Basidiobolus* (Pl. 9, fig. 16), figures a mode

of germination in this genus of a related type; but as the author describes the swollen extremity of the conidiophore as a *basidium*, the similarity is not so striking as a comparison of this with fig. 119, for example, in the present paper, would lead one to infer.

Cystidia and rhizoids.—Before leaving the conidia and conidiophores, two additional structures must be mentioned, which are of some importance morphologically. These are the so-called *cystidia*, or paraphyses as they have been called; and a modification of certain hyphae, known as *rhizoids*, which serve to attach the host to the substratum on which it rests. The cystidia are usually simple hyphae, exceeding the conidiophores in size, and projecting beyond them, often to a considerable distance. In some instances they are very large (fig. 306), and readily seen with the naked eye; while in others they do not differ from the conidiophores. They are not, I think, homologues of paraphyses in other fungi, and their office is unknown; unless, perhaps, they may be considered as rhizoids which are functionless from their position; an explanation which seems to me very probable. A modification of the paraphyses should be mentioned which occurs in *E. echinospora*, a species in which, contrary to the usual type, the zygospores are very commonly produced externally. In this case, when the sporophores have emerged from the host, certain of their number may be seen projecting beyond the rest (fig. 297). While the process of spore formation is going on, these hyphae grow rapidly, forming ultimately a delicate network about the mass of mature zygospores.

The hyphae of attachment, or rhizoids as they may be conveniently termed, consist of hyphae which, growing from the lower and outer portions of the fungus mass, attach themselves to the substratum upon which the host rests and serve to hold it firmly in position. The rhizoids may be simple or variously branched, and their termination may be variously modified into an expanded "sucker" (fig. 249). They do not, I think, enter into soft substances, and their adhesion is apparently due to the presence of a viscous secretion. They are produced with great rapidity, appearing even before the host is dead, and increasing in number with the appearance of the conidiophores. Rhizoids are confined to certain species, and generally accompany the digitate type of conidiophores; their presence should not, however, in my opinion, be considered of any importance as a generic distinction.

It is now necessary to return once more to the condition in which we find the host filled with chlamydospores, or hyphal bodies, in order to examine the phenomena connected with the

Formation of zygospores and azygospores.—As has been previously remarked, the germination of the hyphal bodies or chlamydospores may result in the production of conidia above described; or may lead to the formation of spores called *resting spores*, of a very different nature, and adapted to withstand successfully conditions that would prove fatal to the conidia in a short time. The passage to this resting condition may be accomplished by a wholly non-sexual process, in which case the resulting spore has been termed an *azygospore*, or by sexual union of a type similar to that found in the Mucorini. The spores thus formed are usually of large size, spherical with one exception; with a highly refractive fatty contents; surrounded by triple walls, the outer thin and representing the wall of the mother cell, the second much thicker, and the inmost usually as thick as or thicker than the other two combined.

The simplest process by which azygospores are formed is presented by the case in which the contents of a hyphal body become directly converted into a resting spore, usually contracting somewhat and surrounding itself with two walls, the normal third wall being represented by that of the hyphal body, within which the spore may be entirely free, or to which it may be closely applied. A modification of this process occurs sometimes in the case of chlamydospores, which may be transformed directly into azygospores by the deposition of a third inner wall.

Azygospores may also be formed in a variety of ways from hyphae of germination arising from chlamydospores or hyphal bodies, or not uncommonly by direct lateral budding from them. In the first case the azygospore may be terminal (fig. 40), at the apex of a hypha of greater or less length, or may bud laterally. This process, which may be readily seen by cultivating chlamydospores in water, resembles at first the analogous formation of conidia; the end of the hypha, however, does not produce a bud, but becomes swollen into a mother cell, which is not separated from the hypha by a cross partition, and within which the double-walled spore is formed. Still another method consists in the production of azygospores interstitially (fig. 81), which is common in certain species and leads to the occurrence of spores having very irregular shapes.

These in general are the more common types of azygosporic formation, of which there are numerous slight modifications. Where true zygospores are formed, a considerable amount of variation is exhibited in the process as it occurs in different species; and although the sexual nature of the spore is beyond question in some instances, it is not so well marked in others, and may, as Nowakowski has suggested, represent a transitional form from the truly sexual to the wholly asexual processes. Such instances are found in *E. sphaerosperma*, a species in which, according to Brefeld, the production of resting spores follows the septation and anastomosis of a mass of hyphae filling the host, the spores being produced laterally from these hyphae without regard to the points of anastomosis. In my own experience I have observed something of this sort in the legs of insects attacked by *E. sphaerosperma* and its near ally *E. occidentalis;* but in the bodies of the hosts examined, which, it should be remarked, were of a very different nature from those (*Pieris* larvae) studied by Brefeld, I found only short, contorted hyphae producing spores apparently in a wholly asexual manner (fig. 217), but associated with them, numerous instances where the budding spore was directly associated with a cross-partition or a slight lip-like fold indicating the previous existence of such a partition (figs. 214–216). Whether spores thus formed should be called zygospores seems at least doubtful, and the partitions described may indicate merely the ordinary division of the hyphae. In a very few cases, however, I have, in these two species, seen a process as well marked as that represented in fig. 197, occurring in the legs of certain hosts where, as a rule, the hyphae attain a considerable length. This certainly looks like true conjugation, and may lead us to cases where the presence of a sexual union is hardly to be questioned. The first instance of the latter class discovered among the Entomophthoreae is that described by Nowakowski[1] in his three new species, *E. conica*, *E. ovispora* and *E. curvispora*. In this type we have hyphae, within or without the body of the host, producing lateral outgrowths at opposite points of two different hyphae, which meet

[1] *l. c.*, A.

midway between the two conjugating cells in a fashion analogous to the similar process in *Spirogyra*. The intervening walls between these two gametes, or conjugating outgrowths, are then absorbed and a mingling of their contents ensues. A bud then appears (fig. 322) on one or both the gametes, which increases rapidly, as a rule appropriating the entire contents of each conjugating cell to form the zygospore. A septation of the hyphae above and below the point of conjugation is often seen, but is not invariable, resembling in this respect the similar process in *Conidiobolus* previously described. It may be mentioned, in passing, that the chief distinction between the two rests on the fact that here we have a zygospore formed by budding, while in *Conidiobolus* the spore is produced directly within one of the conjugating cells. In this, as in other cases, the empty hyphae disappear rapidly after the zygospores have been formed; a circumstance which, together with the rapidity of the process as a whole, accounts for the infrequency with which conjugation in *Empusae* can be observed. In one case, however (*E. rhizospora*), the hyphae after conjugation become brown and horny, holding the spores firmly in a spongy mass (fig. 374); but even here the process of conjugation can only be seen during a short period, while the spore is developing, owing to the subsequent contraction and distortion of the hyphae.

In *E. echinospora*, in which the zygospores are often external, a modification of this *Spirogyra*-like process is found, which deserves to be mentioned. Here (figs. 298–302), we have a conjugation taking place between two filaments in a manner similar to that described above; but, instead of arising by budding from one of the gametes or in their immediate vicinity, the spore commonly develops as a terminal swelling from the end of one of the conjugating hyphae.

In addition to these types of conjugation, a singular form, not, I believe, noticed hitherto in Entomophthoreae, occurs in *E. Fresenii*. It is, as far as I have observed, invariable in this species and is never associated, as is usually the case, with the production of azygospores. The hyphal bodies, as they occur in the host just prior to the production of conidia or zygospores, are almost perfectly spherical and very uniform; and are derived from large, shapeless bodies which have the appearance of naked protoplasm. The spherical hyphal bodies lying side by side within the host proceed to conjugate in a manner indicated in the succession of figures 127 to 135. A slight projection first appears from the upper inner end of either hyphal body (fig. 128). These projections soon meet midway between the hyphal bodies (fig. 129), after which a bud begins to rise directly above their point of union (fig. 130). The contents of both bodies pass into this bud, forming the mother cell of an elliptical zygospore which, I believe, affords the only known exception to the usual spherical shape. After the spore is mature, the two hyphal bodies usually persist for some time as bladder-like appendages (figs. 135–136), which slowly disappear (figs. 137–140).

This is certainly a very simple process, yet it demonstrates I think, more clearly than has yet been possible among Entomophthoreae the existence of an undoubtedly sexual process of a distinctly zygosporic type. In *Conidiobolus*, *Basidiobolus*, and even in the examples from *Empusa* previously given, there is usually a more or less marked difference in the size of the gametes, which, in the first-named genus, led Brefeld to consider the family as belonging to the Oosporeae; but, in the present instance, we have the ga-

metes exactly alike, and in addition to this a process of development in the zygospore similar to that occurring among the Mucorini in *Piptocephalis*. The regularity of this process, and of the resulting zygospores, is worthy of mention; and although the hyphal bodies are collected in an indiscriminate mass, the details of the process never show the slightest variation from that described above.

Before leaving the subject of conjugation in Empusae, a singular method, by which the resting spores of *E. Grylli* are often formed, must be described. This species is remarkable for the great variety it exhibits in the details of the formation of its azygospores; but in certain cases it seems not impossible that even in this species we may have true conjugation of a type quite different from those previously described. The successive figures, 31 to 35, indicate the nature of this process. In the first place we have, before reproduction of either type, a condition characterized by the presence of irregular, rounded hyphal bodies of various size and shape (fig. 31). Instead of producing an azygospore by any of the methods above described, one of these bodies may become septate by the formation of a median cross partition (fig. 32). An elevation of the cell wall presently appears around the hyphal body, between the cells thus formed, which develops into a two-lipped fold (figs. 33 and 34). The partition between these two cells is then apparently absorbed, for the contents of one gradually pass into the other to form a "zygospore" (fig. 35). A variation of this process is found in the similar division of the swollen extremity of a hypha (figs. 38–39) the lip-like folds in each being quite peculiar. In many cases the formation of a resting spore is not accomplished by a single division and subsequent union; but only results after a succession of oblique divisions always accompanied by the lip-like folds, as in figs. 36 and 37. Spores of this kind are usually characterized by their flattened bases, and in some instances two such spores may be formed, one in either cell of the divided hyphal body, as often occurs in other conjugating cells. Whether this is in reality a form of conjugation, I do not feel prepared to say; and careful observations, by means of cultivations of the hyphal bodies, are much to be desired. This process may in a measure explain the appearance previously alluded to (p. 147) and represented in figs. 214–216. Here there is no production of a lip-like fold, yet it seems not impossible that in such cases a short hypha may have divided and conjugated with itself, so to speak; the zygospore arising as a lateral bud instead of developing directly within one of the divisions. Such an explanation may seem somewhat far-fetched, yet the division of a hypha and subsequent conjugation with itself are practically what occurs even in *Basidiobolus*.

The mature azygospores as well as the zygospores in all known species are, with the exception of *E. Fresenii*, spherical in shape; and in the majority of cases are indistinguishable in the different species, except by slight variations of size. There are, however, three notable exceptions to this rule. The spores of *Tarichium megaspermum* Cohn[1] are characterized by a deep brown outer wall, or *epispore*, which is marked by sinuous reticulations. In *E. echinospora* (figs. 303–305), the epispore develops numerous sharp spines which separate it from all other known species; while in *E. rhizospora* the brownish spore is held by numerous rhizoid-like outgrowths from its base (figs. 374–375). A dark brown epispore seems also characteristic of *E. calliphorae* Giard (*E. muscirora* Schroeter).

[1] *l. c.* B.

In my own experience, I have never observed the germination of resting spores in any instance, although I have continued cultivations of them in water for upwards of three months. I have not, however, had an opportunity of adopting the plan suggested by Eidam of cultivating them in nutritive solutions, and a trial of this method might lead to more satisfactory results. A germination of the resting spores of certain species is reported by Nowakowski, Sorokin and Krasilstchik; and the first-named author states that such spores placed in water in the autumn germinate during the following spring. I have, however, seen no account of successful cultures of this nature unless it exists in the text of Nowakowski. The description given by Krasilstchik of a species (*E. uvella*), in which he obtained a germination in *four days*, seems hardly reconcilable with the facts as known in other genera. From analogy with *Basidiobolus* and *Conidiobolus*, it is not to be questioned that the resting spores germinate, as in these cases, producing the usual conidia; but whether this has been determined by actual experiment, I am unable to say. The period of rest before germination is probably very variable, and its primary object is, of course, to afford a means of hibernation, or of withstanding similar protracted conditions unfavorable to development, and of long duration. Although a single season is probably the normal period of this resting state, it has been suggested by Brefeld that it may be extended over more than one season, thus allowing the insect host to recover from the effects of *Empusa* epidemics.

The causes which induce the formation of resting spores can be explained with as little satisfaction among Empusae as in other similar cases. The observations of Brefeld in his experiments with *E. sphaerosperma* Fres. (*E. radicans* Bref.), which indicated that their production takes place towards the end of the season, gradually supplanting the conidial form, are not corroborated by my own experience. This, at least, does not seem to be the course followed in the natural development of the fungus out-of-doors; since the examination of some thousand or more of specimens shows that as a rule the relative number of individuals of a given species, which contain resting spores, remains about the same from the middle of June to the middle of October. Whether the production of resting spores bears any relation to the number of previous generations of conidia is a matter to be determined only by careful and repeated cultures in different cases. None of the remaining causes usually assigned as inducing zygosporic formation have any apparent influence in the present instance. But here also repeated experiments in different cases, under known and variable conditions of moisture, temperature and nutrition, are necessary to determine whether variation in these respects seems to have any definite connection with the kind of spores produced.

The hosts of Empusae include representatives from all the hexapod orders; but among them the Diptera are the greatest sufferers, at least in so far as the number of Empusae which prey upon them is concerned. The Hemiptera come next, followed by the Lepidoptera and Coleoptera; while the Neuroptera, Hymenoptera and Orthoptera are about equally affected, and are attacked by two or three species, only, in each instance. The liability to infection is shared by both larvae and pupae as well as by imagines, although the latter are most commonly affected. In insects where the larvae and pupae differ but slightly from the imago, both these stages are equally susceptible to the disease. Mr. L. O. Howard has also shown me specimens of *E. Grylli* that had devel-

oped upon the common web worm (*Hyphantria textor*) *after* pupation; but this occurrence is certainly unusual. Among Lepidoptera, I have been surprised to find the imagines attacked in numerous instances, a fact, I believe, not hitherto observed; and one species (*E. geometralis*) seems peculiar to them. Geometridae, Noctuidae and Tineidae may be affected, and I have even found the common sulphur butterfly (*Colias philodice*) thus attacked. The species or family of the host has hitherto been generally considered a means of determining the species of *Empusa*, in most cases, with some accuracy; yet my observations have shown that this is by no means the case and that specific distinctions, based largely upon the character of the host, are of little value. The variety of hosts attacked by a single species is sometimes very great, perhaps in no instance more so than in *E. sphaerosperma*. I have specimens of this form upon the larva of *Pieris*, on the imago of *Colias philodice*, Diptera of several families and genera, *Phytonomus* larvae (Coleoptera), the common rose-leaf hopper (*Typhlocyba*) and *Aphis* (Hemiptera), on ichneumons of several genera and a small bee (Hymenoptera), and on a species of *Thrips* (Thripidae), while in Europe it is also recorded on *Limnophilus* (Nemoptera). With such a diversity possible in the hosts, it is obviously unsafe to describe, as new species, forms without peculiar characters of their own, merely because they occur in a new host, or to give any considerable specific weight to the character of the host in support of slight variations in the shape of the conidia or the size of the resting spores.

In certain instances, where several Empusae were found together, I have noticed two species developed upon a single host; for example, *E. Aphidis* and *E. Fresenii*, as well as *E. conica* and *E. papillata; E. gracilis* and *E. variabilis; E. lageniformis* and *E. occidentalis*. It is, therefore, not always safe, where such proximity exists, to refer the resting spores that may occur in connection with conidia to the same species of *Empusa*.

The habitat of Empusae is various, one of the most productive localities being the margins of brooks in shady woods. Certain species are found only in such situations, adhering to wet substances, such as moss, logs, stones, etc., in the water or along its margin; a constant supply of moisture being apparently necessary for their development. In other cases dryer situations are preferred, and the fungus readily withstands the alternate dryness and moisture consequent upon the variations of weather, producing its conidia repeatedly, whenever the atmosphere is sufficiently moist, until the conidiophores are exhausted. Many hosts, before death, seek conspicuous positions by crawling upwards on grass, or other substances, whence the conidia are discharged over a considerable area. Perhaps the favorite position assumed by hosts before death is upon the under side of leaves in shady situations in woods or about houses, where a careful search during wet weather seldom fails to disclose numerous specimens. I have noticed only one species which occurs on flowers attractive to insects, namely *E. Muscae;* which, although common in all parts of houses, I have only seen in nature on the flowers of *Solidago* and contain certain Umbelliferae.

Miscellaneous notes.—In collecting Empusae I have found that, as a rule, foggy weather is the most favorable for the purpose, since they are more conspicuous when distended by moisture. A shallow tin box, partly filled with moist *Sphagnum*, is a con-

venient receptacle for specimens; and the latter should be kept separate. In the laboratory each specimen should be inverted over a slide or cover in a moist chamber, until a sufficient number of conidia have been discharged, when it may be dried for the herbarium. Conidia, obtained in this way, may usually be kept for reference for an indefinite period; and, since they allow the comparison of very large numbers of spores side by side, are most convenient for study.

The artificial propagation of Empusae, by the infection of fresh hosts, I have found a much more difficult matter than one would suppose, even when the host infected was of the same species as that from which the spores were obtained for this purpose. Infection between dissimilar hosts I have found still more difficult; although, in two instances, I have been successful in infecting caterpillars with *E. Grylli* developed on grasshoppers, as well as in transferring *E. sphaerosperma* from leaf hoppers (*Typhlocyba*) to a *Pieris* larva. The method which I have adopted for infection consists in the use of a tightly-covered jelly tumbler in which the upper portion is separated from the lower by a round piece of wire netting. By placing the hosts to be infected in the lower of the two chambers thus formed and fastening a specimen of *Empusa* in the upper one, the living hosts below can hardly escape the spores discharged through the netting.

The period which ensues after the infection of a host until its death varies to some extent. In the larger hosts, such as flies or caterpillars, death may not take place for twelve days; although the usual period is from five to eight days. In minute hosts this period must be considerably shortened, owing to the ephemeral character of many forms known to be subject to the attack of Empusae. The first visible symptom of the disease is a general restlessness of the host. In caterpillars, for instance, the insect leaves its food plant and wanders restlessly about; usually endeavoring to climb upwards before death, which is apparently quite sudden and unaccompanied by contortions of the body. The host insect thus remains clinging to the object on which it rests or is fastened to it by rhizoids. Certain insects are fixed by the insertion of their probosces into the substratum on which they rest, as is the case with aphides. The house-fly is, I believe, always fastened by its proboscis which adheres firmly to the substratum. Where rhizoids are developed, they often appear before the death of the host, and I have seen a geometrid moth, which was thus firmly attached to a pine needle, fluttering violently in its attempts to escape.

In the account of the separate species of Empusae which follows I have used this generic name for all the forms, employing the names *Entomophthora* and *Triplosporium* in brackets as groups of subgeneric value. In *Empusa proper* I have included forms in which the branching of the conidiophores is of the simple type, and the formation of resting spores presumably asexual, taking *E. Muscae* as the type. Under *Triplosporium*, I have included the two forms *E. Fresenii* and *E. lageniformis*, the position of which in *Empusa* is only provisional. The group is characterized by the production of conidia having a smoky tint, thick-walled, with evenly granular contents and producing peculiar almond-shaped secondary conidia on capillary conidiophores; while its zygospores are elliptical, each originating as a bud which rises upward from the point of conjugation of gametes arising from two hyphal bodies. Further study of *E. lageniformis* may

show that these characters, as regards the formation of resting spores, are not sufficiently distinctive. Yet I doubt if this proves to be the case; and, should it prove otherwise, I believe that the subgenus should be separated as a genus from other Empusae.

Under *Entomophthora*, which I have used in brackets as a subgenus, I have included all forms characterized by the production of typically digitate conidiophores; differing from recent German writers in not considering this character of generic value, as well as in omitting even as a subgenus the name *Lamia* given by Nowakowski to a single form (*E. Culicis*).

In his extended paper on Entomophthoreae,[1] Nowakowski summarizes the generic distinctions of *Empusa*, *Entomophthora* and of his genus *Lamia*, as follows:

1. Entomophthora including *ovispora*, *curvispora*, *conica*, and *Aphidis*.
   Fungus growth, one-celled or with filamentous branches.
   Paraphyses, *rhizoids* and *columella*, present.
   Conidiophores, branched.
   Resting spores, zygospores (three species), azygospores (two species).
2. Lamia including the single form *Culicis*.
   Fungus growth, filamentous.
   Paraphyses, present.
   Rhizoids and *columella*, absent (*nie ma*).
   Conidiophores, unbranched.
   Resting spores, azygospores (borne terminally).
3. Empusa including *Grylli*, *Fresenii* and *Muscae*.
   Fungus growth, filamentous.
   Paraphyses and *rhizoids*, absent.
   Columella, present or absent.
   Conidiophores, simple.
   Resting spores, azygospores.

Whether Nowakowski in his text gives more satisfactory characters for the genus *Lamia* than are shown in the above table I am unable to say; but, from the data here given, the presence of paraphyses (which I have apparently overlooked in examining the species) is the single point which separates it from *Empusa* as defined below it. The opinion of Brefeld that the form should be separated as a connecting link between *Empusa* and *Entomophthora*, based upon a tendency to a digitate type observable in the conidiophores and upon the presence of rhizoids is more readily understood, yet singularly enough, and erroneously I think, Nowakowski affirms the absence of both these points of structure. In my own opinion, *E. Culicis* cannot be separated from *E. Muscae* by other than specific distinctions; the points of similarity of the two being decidedly greater than their points of difference. The same may be said of the two species subsequently described as *E. papillata* and *E. apiculata* which bear somewhat the same relation to *E. Grylli* that *E. Culicis* does to *E. Muscae;* each having rhizoids and showing a slight tendency, in the case of *E. apiculata* at least, to a digitate type of conidiophores.

Taking the genus *Entomophthora*, as defined by Nowakowski in the same table, the digitation of the conidiophores is apparently the only exclusive difference of importance which separates it from *Empusa*. Even here *E. Culicis* and *E. apiculata* tend to break

[1] *l. c.* **B**, p. 176.

down the distinction, as already mentioned. No definite line can be drawn, also, as concerns the production of resting spores; since in species of the *sphaerosperma* type, which must be placed in *Entomophthora*, we have exactly the same type of formation with that occurring in *E. apiculata*, which it is equally necessary to place in *Empusa*. It is true that conjugation is not known in *Empusa* unless it is represented in the very questionable type described under *E. Grylli;* yet it is unsafe to assume that it does not exist, or that its *absence* is of generic value. The only consistent way out of the dilemma consists either in considering all the forms under the tolerably coherent genus *Empusa*, or in resorting to further splitting to express transitional forms. The *sphaerosperma* section of *Entomophthora*, for example, shows decided differences from the rest of the group in the character of its branching, in its conidia and secondary conidia as well as in its formation of resting spores, and may, perhaps, with fuller knowledge of the species already known or subsequently to be discovered, prove separable from the remaining forms. Our knowledge of Empusae is at present in its infancy, and conclusions in respect to subdivisions must be largely based on doubts; a foundation much more likely to produce confusion than a clear understanding of the group.

The use of the name *Empusa* in preference to *Entomophthora* needs a word of explanation, since the two have, until comparatively recent years, been used in the same sense to designate entomogenous Entomophthoreae generally. Although an *Empusa* had been previously described by Fries under an erroneous generic name (*Sporendonema*), the paper of Cohn[1] upon the "house-fly fungus" is the first in which the group was recognized by a generic title, *Empusa*. This publication appeared in 1855, and in the following year Fresenius, in an article[1] preliminary to his more extended paper on the subject,[2] pointed out that *Empusa*, having been preoccupied for a genus of orchids, should be dropped, proposing *Entomophthora* in its place. A few months later Lebert,[3] taking the same ground, proposed the name *Myiophyton*, over which the name of Fresenius of course has priority. The two names have subsequently been used indiscriminately until separated as two distinct genera by Brefeld and Nowakowski, who thus tacitly recognized the validity of *Empusa* as a name; a validity also admitted by Cohn, Eidam, Schroeter and DeBary who employ it without question. If therefore a single name is to be used, *Empusa* certainly has priority and sufficient weight of authority to make its use good. As a matter of fact the orchidaceous genus *Empusa* is placed as a synonym in Bentham and Hooker's Genera Plantarum, and seems unlikely to produce confusion in any case.

The position of the Entomophthoreae among the Zygomycetes is placed beyond a doubt by the formation of the resting spores above described, yet it is interesting to note that, until the publications of Nowakowski, and even subsequently, there has been much difference of opinion concerning their true position; the weight of opinion assigning them a place among the Oosporeae. The theory that the members of the group were merely stages in the life-history of Saprolegniae, which has been maintained on a basis of actual experiments as well as their supposed connection with the yeasts (*Saccharomyces*), is manifestly incorrect and a matter of historical interest only. In the latter case it is of interest to note that species of *Saccharomyces* very frequently occur in connection with

[1] *l. c.* A. [2] *l. c.* B. [3] *l. c.*

Empusae in aphides and flies, the one class of hosts usually having a sweet secretion and the other preferring sweet substances as food, thus supplying a nutritive medium for the growth of yeasts in connection with the *Empusa*. It has occurred to me that the frequent presence of yeasts in this connection might indicate a sweetish secretion from the *Empusa* itself in order to attract hosts for infection; but I have seen no indications that this is the fact.

A natural arrangement of the species of *Empusa* is a matter of great difficulty, since their characters do not, I think, indicate a single line of development. In the succeeding enumeration, for example, the two forms included under *Triplosporium* can hardly be properly placed either at the beginning or at the end of the remaining series, and their position between *Empusa* proper and *Entomophthora* is equally unsatisfactory. The near relations of the forms described as *E. Caroliniana* and *E. Lampyridarum* is also a matter of doubt which may perhaps be removed by further study. A list of the remaining species found in Europe and not yet distinguished in this country, with brief characters and references, is appended for the convenience of students and includes, I believe, all published names not previously referred to. References given as *l. c.*, *l. c.* **A**, etc., refer, as in the previous pages, to the appended list of papers consulted where full titles and references are given.

Empusa Cohn, 1855.

Empusa Muscae Cohn.

Pl. 14, figs. 1–9.

Empusa Muscae, Cohn *l. c.* **A**. Brefeld *l. c.* **A**; *l. c.* **B**, p. 28; *l. c.* **C**. Schroeter *l. c.*, p. 221. Nowakowski *l. c.* **B**, p. 176.

Entomophthora Muscae, Fresenius *l. c.* **A**, p. 883; *l. c.* **B**, p. 202, figs. 1–23. Giard *l. c.*, p. 358. Sorokin *l. c.* **C**, p. 195, figs. 377, 582–585. Winter *l. c.*

Myiophyton Cohnii, Lebert *l. c.*

?*Sporendonema Muscae*, Fries *l. c.*

Conidia bell-shaped or nearly spherical, with a broad subtruncate base and sharply pointed apex; $18\times20\mu$–$25\times30\mu$; containing usually a single large oil globule, and surrounded after discharge by a mass of protoplasm. *Conidiophores* simple, broad and stout, tapering gradually to a narrow base; emerging in white rings between the segments of the host, without coalescing over its body. *Secondary conidia* like the primary, or more commonly subovoid, small, rounded at the apex and formed by direct budding from the primary form. *Resting spores*, azygospores, produced laterally or terminally from hyphae within the host; spherical, colorless, 30–50μ in diameter (Winter). Host attached to substratum by proboscis.

Hosts. Diptera: *Musca domestica*, *Lucilia Caesar*, *Calliphora vomitoria* and other large flies; also Syrphidae of several genera.

Habitat. United States, Europe, South America.

This familiar *Empusa* is as common as it is widely distributed, and is at present the only species known south of the equator. It is probable that it is as universal as its more

usual host (*Musca domestica*); since, if not indigenous in remote localities, its transportation by sea would be almost inevitable. As a rule, the species is found about houses, usually within them, occurring in great abundance from the latter part of June until late in the autumn; yet its occurrence out-of-doors is an exceptional phenomenon and has been noticed in only a few cases. This is the more singular, since hosts that are liable to infection are very common in the open air, and a transmission to them of the disease from the house-fly would seem a very easy matter. Isolated examples of *E. Muscae* are, however, almost never found in situations frequented, for instance, by *Syrphus* flies, although Cornu[1] records an extensive epidemic in which the hosts attacked belonged to this genus. In my own experience I know of only two instances of the isolated occurrence of this species out-of-doors. The first was observed early in July on Mt. Washington where two small specimens of *Syrphus* were found on bushes in the alpine region, both of which were infested by *E. Muscae;* and in the second instance a specimen of a small, yellow-bodied *Syrphus* was found at Albany in August on the flowers of *Solidago* by Mr. A. F. Chatfield, and forwarded to me, the host in this case being attacked by the same *Empusa*. Mr. Chatfield informs me that it was the only specimen observed, and although I have searched with great care for similar specimens, I have never seen a second instance of the kind. An epidemic in the open air, caused by *E. Muscae*, I have, however, observed in one locality where a hairy black fly (*Anthomyia sp.*) about as large as *M. domestica*, was found killed by this fungus. This locality was the region in the immediate vicinity of the snow arch at the head of Tuckerman's ravine, on Mt. Washington, where the affected flies occurred sticking in large numbers to the flowers of *Solidago* and *Heracleum*. These flowers were also visited by an abundance of other flies, among them many examples of the same species of *Syrphus* previously mentioned from Mt. Washington and Albany; but in no instance did I find one of these or of the numerous other Syrphidae and Muscidae visiting the flowers, that showed any signs of infection from the black flies with which they could hardly have failed to come in contact. This failure of certain species to contract the disease, although known to be subject to it, is interesting as indicating that even a slight change of hosts among *Empusae* is often difficult, until the fungus has become established to some extent in its new conditions, and may go far to explain the difficulty experienced in cross infection subsequently mentioned under *E. Grylli* and *E. sphaerosperma*.

The species is readily distinguished by its pointed, bell-shaped spores which, although entirely similar to those of *E. Culicis*, are much larger. The probable rupture of the columella has been previously alluded to (p. 144) and the surrounding pellicle of protoplasm gives a characteristic appearance to spores which, for example, have been discharged upon a glass slide (figs. 5–6). One of the chief points of interest about the species is the uncertainty that exists concerning its resting spores, which, although the form is so universal, have as yet been observed in only one instance. Winter[2] states that he discovered specimens of *M. domestica* in-doors which contained resting spores, and also produced conidia which he identified as belonging to *E. Muscae*. It seems quite impossible that Winter should have mistaken the conidia of any other species for those of *E. Muscae;* yet this observation, although referred to, is not credited by Brefeld, who concludes

[1] *l. c.* B. [2] *l. c.*

that the species never produces resting spores and is continued over winter in warmer regions, whence it migrates northward with the flies on the return of summer. This theory, however, does not coincide with my own experience of *E. Muscae* in this country; since the first specimen which I observed at Cullowhee, where *M. domestica* literally swarmed, was observed at about the same date at which it usually appears in the north, namely July first. For three weeks previous to this date I saw no specimens at Cullowhee; and although I have found not the smallest trace of resting spores in a single instance, it seems improbable that the migration theory can apply to this country at least.

Giard[1] also states that he found resting spores, which were produced externally, occurring on specimens found in cool situations; but it is difficult to determine from his description whether the bodies described are true resting spores, and the observation needs confirmation. On plate I, fig. 7 and plate II, fig. 12, of Lebert's paper,[1] this author has also figured bodies that seem to be resting spores at an early stage of their formation.

The literature concerning *E. Muscae* is very voluminous; the first description of the form having been given by DeGeer in 1782, according to Brefeld; and for further references to this literature the elaborate papers of Cohn, Lebert and Brefeld above cited should be consulted. Whether the first supposed description accompanied by a distinctive name, that of Fries,[1] really applies to the present species is, I think, extremely doubtful; for the oil globules in *E. Muscae* could hardly have given rise to the expression "flocci fertiles erecti, ... intus sporidiis globosis referti," whereas in species of the *ovispora* type, this error of observation might readily have occurred.

Empusa Culicis A. Braun.

Pl. 14, figs. 10–16.

Empusa Culicis, A. Braun *l. c.*, p. 105.
Entomophthora Culicis, Fresenius *l. c.* **B**, figs. 44–45.
Lamia Culicis, Nowakowski *l. c.* **B**, p. 173, figs. 99–114.
Entomophthora rimosa, Sorokin *l. c.* **A**, p. 146; *l. c.* **B**, p. 393, Taf. XIII, figs. 12–19 (with cut); *l. c.* **C**, p. 231, figs. 595–596, 575, 576, 603; *l. c.* **D**, p. 58, plate I, figs. 1-13. Nec *E. rimosa*, Schroeter *l. c.*, p. 222.
?*Saprolegina minor*, Kützing *l. c.*, p. 157.

Conidia bell-shaped or nearly spherical with a broad subtruncate base and sharply pointed apex; $8 \times 10\mu - 15 \times 16\mu$, average $11.5 \times 12\mu$; usually containing a single large oil globule, and surrounded after discharge by a mass of protoplasm. *Conidiophores* simple or with a tendency to become compound; broad at the apex and gradually tapering to a narrow base; producing white or greenish masses which may or may not coalesce over the body of the host. *Cystidia* present (Nowakowski). *Secondary conidia* like the primary, or ovoid with rounded apex and formed by direct budding from the primary spore. *Resting spores*, azygospores, produced laterally or terminally from hyphae, spherical, colorless, 25μ (? in diameter). Host attached by rhizoids.

[1] *l. c.*

Hosts. Diptera: imagines of *Culex* and numerous genera of minute flies or gnats.
Habitat. Maine, New Hampshire, Massachusetts, Europe.

This is apparently the smallest of all the Empusae and is reported to be common in various parts of Europe. Although not previously accredited to this country, I have found it repeatedly in the localities above mentioned. At Kittery, Maine, it occurred early in July on very minute Diptera, adhering to the under side of the leaves of hop, hollyhoek and other plants growing about houses; and isolated specimens were found in similar positions in the neighboring woods, or marshy places. Although mosquitoes (*Culex*) abounded in these localities, the only specimen of this insect that I have seen infested with *E. Culicis* was found on the edge of a small brook in the alpine region of Mt. Washington. In this same locality, at the head of Tuckerman's ravine, I have found an insect also attacked by *E. Culicis*, whose reputation is perhaps worse even than that of the mosquito, namely the "black fly" (*Simulium molestum*). These specimens were also found upon the under side of leaves, as in the case of the examples from Kittery; although in Europe the more usual habitat seems to be such moist situations as are afforded by the margins of brooks or the borders of tanks, in which, also, infected specimens may often be found floating.

The form described by Sorokin as *E. rimosa* seems certainly to belong to this species, as has been pointed out by Nowakowski, although Sorokin, in his later publications, still adheres to the opinion that his species is distinct. In describing *E. rimosa*,[1] Sorokin states that the host is attached by rhizoids, and that the conidiophores appear on the thorax, seldom on the abdomen of the hosts, producing bell-shaped conidia of which, so far as I have seen, he gives no measurements in any of his publications. The resting spores he describes as of irregular outline, produced laterally on internal hyphae, which subsequently thicken, contract and, bursting the body of the insect, assume a vertical position on the outside. He also remarks that, from the brief description of A. Braun, it is difficult to say how far the two species (*E. rimosa* and *E. Culicis*) are distinguished. The figures of Fresenius from material received from Braun are, however, good, and correspond to those of Sorokin in Cohn's Beitrage.[2]

As regards the "stroma," which Sorokin describes in this species, I have been unable to satisfy myself; but where the fungus has developed with tolerable luxuriance I have found a condition very like that which he describes; namely, a mass of septate, anastomosing, empty hyphae filling the body of the insect. In other cases, however, I have observed the presence of spherical hyphal bodies or of chlamydospores (fig. 15), which germinated and, after more or less branching, produced conidiophores in the usual way. The resting spores are unknown to me, although I have frequently found small flies containing resting spores in company with the conidial form. In these cases the constant association with specimens of *E. sphaerosperma* on similar hosts has made it impossible to determine to which species the resting form belonged. According to the description of Sorokin above quoted the resting spores would seem to be quite peculiar; yet Nowakowski figures spores of the usual type borne terminally on long hyphae.

[1] *l. c.* **C**, p. 231.

[2] *l. c.* **B**, Taf. XIII, figs. 16–18.

Empusa Grylli (Fresenius).

Pl. 14, figs. 17–48.

Entomophthora Grylli, Fresenius *l. c.* **A**; *l. c.* **B**, p. 203, figs. 24–43. Sorokin *l. c.* **C**, p. 211, fig. 653. Farlow, Ellis Exsiccati N. A. Fungi, No. 1401.

Empusa Grylli, Nowakowski *l. c.* **B**, p. 168, figs. 72–98. Schroeter *l. c.*, p. 222.

Entomophthora aulicae, Reichhardt in lit. (see Bail *l. c.*). Cohn *l. c.* **B**, p. 77. Sorokin *l. c.* **C**, p. 212. Schroeter *l. c.*, p. 221.

Entomophthora Calopteni, Bessey *l. c.*; Ellis Exsiccati, No. 1801.

Conidia ovoid to pear-shaped, with a broad papillate base and evenly rounded apex; 30–40μ × 25–36μ; hyaline and containing one or more large fat globules. *Conidiophores* simple, coalescing externally when growing luxuriantly, and arising directly from rounded irregular hyphal bodies, with or without subsequent branching. *Cystidia* wanting. *Secondary conidia* of one kind, like the primary. *Resting spores* spherical, colorless; 30–45μ in diameter; produced terminally or laterally from hyphae, directly within or by budding from hyphal bodies; or by a pseudo-conjugation between two divisions of a single hyphal body. Host attached to substratum by the contraction of its legs.

Hosts. Lepidoptera: larvae of many genera of Arctians and of *Orgyia nova*. Orthoptera: larvae, pupae and imagines of many genera of Acridians. Imago of *Ceuthophilus*. ? Diptera: larvae and imagos of Tipulidae, etc. (see *E. conglomerata*).

Habitat. Maine, New Hampshire, Massachusetts, New York, Washington, D. C., North Carolina, Ohio, Iowa, Newfoundland, Europe.

As will be observed, by the synonymy given above, I have included under this species the two forms described as *E. aulicae* and *E. Calopteni*. The description of the first-mentioned species by Cohn[1] is, I believe, the first mention of this name that is accompanied by any note which would render a determination possible. There can be no doubt, I think, that the form common in this country on hairy caterpillars is the same species described from Europe on similar hosts, since the American form agrees with the European in all respects as far as can be ascertained from published data. Assuming this identity, a comparison of the form on caterpillars and the still more common form on grasshoppers, can hardly fail to afford convincing proof that the two represent a single species, their general structure, development and appearance being the same, or varying within similar limits.

I have observed numerous epidemics of the grasshopper form at Kittery in Maine, near Boston and in North Carolina; and the caterpillar form seems also very common, assuming, Mr. Howard informs me, an epidemic character among the *Hyphantria* larvae which have recently done considerable damage to the shade trees in Washington.

In the summer of 1886, I found an epidemic early in September among grasshoppers that were destroying the second crop in a field at Kittery, and also noticed a number of Arctian larvae similarly affected in an adjacent garden. Being struck with the similarity between the two, I endeavored to transfer the disease from the grasshoppers to caterpillars, and for this purpose placed a larva of *Spilosoma virginica* and several of

[1] *l. c.*, p. 78.

Hyphantria textor in a jelly tumbler, and fastened above them a grasshopper from which the spores were being rapidly discharged. These larvae were then fed for eight days in a closed jelly tumbler, at the end of which time the *Spilosoma* had died, and, soon after being placed in a moist chamber, produced a luxuriant growth of conidiophores. In the meantime all of the *Hyphantria* larvae had died from insect parasites, with the exception of two which spun cocoons after a few days. I was entirely unable to transfer the disease from caterpillars to grasshoppers; but I was quite as unsuccessful in infecting grasshoppers from grasshoppers. The reinfection of caterpillars I found more easy, although about two-thirds of the caterpillars used for this purpose showed no signs of the disease and pupated as usual. I was unable to repeat the experiment of cross infection with any satisfactory result, owing to the fact that it was impossible to obtain caterpillars in any number, or good material of *E. Grylli* with which to infect them: I was obliged therefore, in a second experiment, to use larvae of *Pyrrharctia isabella* which were in the hibernating condition. Of five larvae used, one died in eight days and contained resting spores; while the rest were not affected after several weeks. I do not consider these experiments as in the smallest degree conclusive in themselves; but a comparison of other species shows that the hosts of Empusae may be widely different in the same species, and therefore a specific distinction, which, as in the present instance, would rest entirely on the character of the host, should not be considered of any value, even if my experiments did not show that the hosts may be, to a certain extent, interchangeable.

I have been much surprised at the difficulty encountered in communicating the disease among similar hosts, although in the case of grasshoppers this may be perhaps accounted for from the fact that I used only imagines, which may afford a less ready entrance to the germinating spores than younger stages of these insects. In the case of the hairy caterpillars, however, I see no reason why infection should not have been successful in every case. A specimen of *Ceuthophilus*, found at Kittery, which was discharging spores in great quantities, was also used in an attempt to infect three individuals of the same species which were confined with it in a small tin box. The living crickets were put into the box late in the afternoon when the spore discharge was at its height, so that several hundred spores at least must have come in contact with each specimen. On the following morning the living crickets were not only well powdered with spores, but had eaten about half of the infected specimen. Nevertheless, after having been kept for more than two weeks, they showed no signs of the disease. In view of these facts, it is not surprising that my success in cross infection should have been so incomplete, and it may reasonably be assumed that so radical a change of hosts is probably a somewhat gradual process even in nature, the fungus, as has been already noted, requiring one or more generations to become firmly established under its new conditions of nutrition.

Since the species is so widely distributed and generally abundant, there seems to me no good reason for believing that the resting spores described as *E. Calopteni* and found in *Caloptenus* at Ames, Iowa, belong to a different species; and I have therefore placed this as a synonym. Through the kindness of Professor Farlow, I have been enabled to examine authentic specimens of *E. Calopteni* collected by Professor Bessey which differ in no respect from the usual resting spores of *E. Grylli*. Professor Farlow has also

allowed me to examine material of *E. Grylli* received from Professor DeBary, and there can be no question concerning the identity of the American and European forms. The occurrence of the species in Newfoundland, where I found it on the larva of *Orgyia nova* on the Salmonier river, should also be noted; since this is, I think, the most northern locality in America from which Empusae have been recorded.

Morphologically, the species is chiefly of interest from the pseudo-conjugation already described on p. 149. I have not had an opportunity of studying the process by cultivations of hyphal bodies; and the figures which represent it (figs. 31–39) are drawn from specimens which occurred simultaneously in a single grasshopper. The process is not uncommon, occurring chiefly in the femora; but in all cases the usual azygospores are by far the most abundant form of resting spores. The production of a double spore by the incomplete union of the two halves of a hyphal body is not infrequent, resulting in forms similar to that represented by fig. 47, in which the union was nearly complete. It sometimes occurs also that there is no union between the two halves, and an azygospore is formed on either side of the median partition. The most common mode by which azygospores are formed is that represented in fig. 43, where the spore is the result of direct budding from the usually irregular hyphal bodies. I have never seen in the caterpillar or in the grasshopper form a process of this kind which is wholly comparable with that figured under *E. conglomerata* (figs. 60–61), for in this case the hyphal bodies are very regular, nearly round, and bear the spores on a short neck. This process is, moreover, invariable in the *Tipula* form as far as I have seen and shows none of the variations which occur in *Grylli*. The same process is figured by Nowakowski,[1] but it is not stated in the explanation of the plates whether these figures are drawn from material on grasshoppers or gnats. The budding, from an arachnoid hyphal body, of spores, which in the explanation of his plates[2] Nowakowski calls "*zygospores*," I have observed in only two cases; but as there seems no indication in this of a sexual process, and Nowakowski in his synoptical table of the species[3] places *E. Grylli* under "Azygospora," I infer that the use of "zygospory" in this connection is a printer's error. A very common form, which I have seen frequently in cultivations of hyphal bodies in water, is that represented in fig. 40, where the spore results from a terminal enlargement of the hypha of germination. A formation from septate hyphae, as in fig. 45, I have seen only once or twice; but the septation as well as the anastomosis and short projections associated with it has, I think, no significance. The occurrence of resting spores is about equally common in caterpillars and in grasshoppers, and the association with them of conidia developed from the same specimen, frequently occurs. The conidia as a rule show little important variation in size or shape, the caterpillar form showing sometimes a tendency to taper more gradually to a slightly broader base than in the grasshopper form; but, on the other hand, I have never seen this tendency so marked in caterpillars as I found it in the spores obtained from the *Ceuthophilus* above mentioned (figs. 25–26).

The earliest occurrence of this species that I have noticed was at Cullowhee, N. C., where I found a single specimen early in July. On the grassy summits of Roan Mt., N. C., it was epidemic in August and also in mowing fields at Cranberry, N. C. An epidemic observed in September at Kittery has already been mentioned; and the latest

[1] *l. c.* B, fig. 94. [2] *l. c.* B, p. 182. [3] *l. c.* B, p. 176.

occurrence that I have noticed was among caterpillars in Cambridge late in October. The tendency of the affected hosts to crawl upwards before death, instead of concealing themselves, as one would naturally expect, is noticeable in this, as in other Empusae, and results in a far more effective dissemination of the spores. The *Ceuthophilus* above mentioned, which usually lives under logs and in similar situations, had crawled up a bush about six feet high and hung suspended from the topmost twigs; grasshoppers also almost invariably crawl nearly to the top of the culms of grass before death, and are thus very conspicuous and easily collected. Mr. Miyabe informs me that he has seen grasshoppers in this position in Japan; but whether the *Empusa* by which they were attacked is *E. Grylli* or not, I am unable to say.

For some mention of European epidemics caused by "*E. aulicae*" which have been noticed as far back as 1835, reference should be made to the papers of Cohn and Bail already cited.

Empusa Tenthredinis (Fresenius).

Pl. 15, figs. 49–55.

Entomophthora Tenthredinis, Fresenius *l. c.* **B**, p. 205, figs. 51–58. Sorokin *l. c.* **C**, p. 212, fig. 652.

Conidia broadly ovoid, tapering slightly towards the apex and with a prominent, rather narrow papillate base; $25 \times 35\mu - 35 \times 55\mu$ (62.5μ = maximum length, sec. Fresenius). *Conidiophores* simple, coalescing over host. *Secondary conidia* like the primary. *Resting spores* unknown. Host attached to substratum by its legs. Rhizoids not observed.

Hosts. Hymenoptera: larvae of Tenthredinidae.

Habitat. Kittery, Maine; Europe.

I have referred to this species a form found early in September upon a small *Tenthredo* larva feeding upon *Scutellaria* in a swampy situation among woods. The larva when found was hanging flaccid by its prolegs, and the conidiophores were just beginning to emerge in small tufts over its body. The spores are somewhat smaller than those described by Fresenius, nor is their difference from *E. Grylli* as decided as represented in Fresenius' plate. A slight tendency to taper more equally from the middle of the spore towards the base and apex, as well as its usually more delicate papilla, may separate it from *Grylli* to which it is closely allied. It is apparently rarely met with even in Europe, the only mention that I have seen beyond that of Fresenius being a reference by Cornu[1] to an *Empusa* on *Tenthredo* larvae. The reference and figure in Sorokin[2] are taken from Fresenius.

Empusa conglomerata (Sorokin)?.

Pl. 15, figs. 56–62.

Entomophthora conglomerata, Sorokin *l. c.* **A**; *l. c.* **B**, p. 388, Taf. XIII, figs. 1–11; *l. c.* **C**, p. 228, figs. 574, 594, 592.

? *Empusa Grylli*, Nowakowski (in part) *l. c.* **B**, p. 168.

[1] *l. c.* **A**, p. 189. [2] *l. c.*

Conidia broadly ovoid, usually with a single large oil globule; $22 \times 25\mu - 25 \times 40\mu$; average $23 \times 32\mu$. *Conidiophores*, simple. *Secondary conidia*, like the primary. *Resting spores*, azygospores, produced from spherical hyphal bodies and borne on a neck-like process of variable length. Host floating on water, or among moss in water.

Hosts. Diptera: larvae and imagines of Tipulae.

Habitat. Mt. Washington, N. H.; Cullowhee, N. C.; Europe (on Culex).

It is with great hesitation that I have referred to this species a form found in the small brooks which arise in the locality known as the Alpine Garden on Mt. Washington and also very rarely at Cullowhee. In the former locality, the *Tipula* larvae were very frequently met with among moss over which water was running. These larvae were dead having a milky color, and after being placed upon slightly damp moss which absorbed the excess of moisture from them, produced conidia with great rapidity; but in not very considerable quantities. On examination, the body was found in every case to be filled with resting spores in various stages of development, and the conidiophores were present in such small numbers that a "stroma," such as is described by Sorokin in this species, would not have been apparent. The conidia closely resemble those of *E. Grylli*, and usually contain a single large oil globule in the centre. The difference in habitat between *E. Grylli* and the present form is certainly very great, and it is doubtful if *E. Grylli* would survive soaking in running water for a week or more as is necessarily the case with the *Tipula* larvae above mentioned. The regular production of resting spores from nearly spherical hyphal bodies is not such as is found in *E. Grylli* and this is the only morphological difference that I have been able to find between the two. Whether material in good condition and free from resting spores would show the "stroma" of Sorokin, remains to be determined; but judging from the spores figured by this author,[1] as well as by the host and habitat, the present form at least approaches very nearly to *E. conglomerata*. Sorokin gives no measurements of the conidia that I have been able to find, but should the measurements correspond, the conidia of the two forms would be indistinguishable. Sorokin states that the conidium is discharged together with a body of protoplasm from the basidium, a circumstance which, in the examination of dried material, I have not been able to verify in the present instance.

In the plates of Nowakowski[1] certain of the figures of *E. Grylli* are drawn from material on *Culex*, and this author is inclined to think that *E. Grylli* and *E. conglomerata* are the same. The figures referred to do not wholly corroborate this view and it may be mentioned that one among them[2] exhibits the same regular formation of resting spores from spherical hyphal bodies that I have represented in figs. 60 and 61.

Empusa apiculata, nov. sp.

Pl. 15, figs. 63–70, 74–75.

Conidia nearly spherical, with a prominent papillate base, terminating in a short, sharp and abrupt point; $28–30\mu \times 30–37\mu$, average $30 \times 35\mu$. *Conidiophores* simple, sometimes with a tendency to become digitate, originating directly or indirectly from nearly

[1] *l. c.* **B.**

[2] *l. c.* **B,** Plate XI, fig. 94.

spherical hyphal bodies. *Secondary conidia* like the primary. *Resting spores*, azygospores or zygospores(?), formed laterally or terminally from hyphae, spherical; hyaline, 30–45μ. Host attached to substratum by long and conspicuous rhizoids, few in number and terminating in an irregular, disc-like expansion.

Hosts. Lepidoptera: larva of *Hyphantria textor*, imagines of *Tortrix* sp., Deltoid sp., *Petrophora* sp. (geometrid). Diptera: numerous genera of small flies or gnats. Hemiptera: imago of a species of leaf hopper (*Typhlocyba*).

Habitat. Maine and North Carolina.

Var. **major.**

Pl. 15, figs. 71–73.

Conidia more nearly spherical; $38 \times 45\mu - 55 \times 60\mu$; basal papilla smaller in proportion to the body of the conidium than in the typical form.

Host. Coleoptera: imago of *Ptilodactyla serricollis* (*fide* Henshaw).

Habitat. Cullowhee, North Carolina.

It is with some reluctance that I have given a new name to this form, although by the presence of strong rhizoids and by its apiculate papilla it seems a well-marked species. The existence of three allied species, *E. Jassi*, *E. Planchoniana* and *E. conglomerata*, concerning neither of which is any information procurable beyond the insufficient data already published, makes the description of a related form necessarily dangerous, so that the present name is in a measure provisional until more complete descriptions or figures of the three forms mentioned are published. The case is rendered still more confusing by the occurrence on aphides of the species described below and placed provisionally under *E. Planchoniana*. This may prove to be the same with the form under consideration, and both may be identical with *E. Planchoniana;* yet, what the latter species is, it is wholly impossible to determine from published data.

In the present species we have the first recorded instance of an *Empusa* growing upon a lepidopterous imago as its host, although, as will be subsequently seen, this is not an unique case. The geometrid moth, above mentioned as one of its hosts, was taken on the wing, flying slowly with an unnatural fluttering motion and being placed in a collecting box it was soon fastened to a leaf by five or six long and powerful rhizoids. These on examination were found to be made up of several hyphae each ending in an irregular expansion (fig. 75) around which a hyaline substance seemed to have been secreted, converting it into a disc-like sucker. Where several of these terminations had touched the leaf at adjacent points the several expansions usually coalesced to form one large "sucker," with a continuous even outline formed by the secretion just mentioned. This moth contained both conidia and resting spores, the latter forming in a manner exactly resembling that subsequently mentioned under *E. sphaerosperma*. The appearance of a resting spore having its origin in connection with a cross partition, as in fig. 74, occurred occasionally and seemed wholly analogous to the similar appearance in *E. sphaerosperma* (figs. 214–216).

The conidiophores, in many instances, arise directly from nearly spherical or elliptical hyphal bodies (fig. 64); but in some cases I have observed a condition where the body

has been filled with a coherent mass of empty, interlacing hyphae resembling the "stroma" described by Sorokin and previously referred to. The conidiophores, which are clear white, coalesce over the body to a great extent, forming an envelope of considerable thickness. They sometimes tend to become digitate, so that this species, together with *E. Culicis*, forms a connecting link between the simple and compound types.

The species occurs not uncommonly in North Carolina on the under side of leaves in *Rhododendron* thickets; and I have found it occasionally in Maine near brooks or marshy places in woods, always on leaves. The specimen on *Hyphantria textor* (larva) was found at Burbank, E. Tenn., in one of the nests peculiar to these caterpillars; but, although there were many in the nest, I found no additional specimens attacked by the fungus. The omnivorous character of the species is noticeable, and experiments with infections of different hosts are much to be desired, especially with aphides, since it is only by this means that the true relations between this and the succeeding form can be determined.

Empusa Planchoniana (Cornu)?.

Pl. 15, figs. 76–78.

Entomophthora Planchoniana, Cornu *l. c.* **A**, pp. 189, 190; *l. c.* **B**, foot-note, p. 4. Sorokin *l. c.* **C**, p. 214.

Conidia nearly spherical or broadly ovoid, with a papillate base which is sometimes furnished with a short sharp point. Average measurements 28–33μ × 30–40μ. *Conidiophores* simple, partially coalescing over the host. *Secondary conidia* like the primary. *Resting spores*, azygospores, produced laterally or terminally, more commonly interstitially, from hyphae; spherical, or very irregular in the interstitial forms; 35–50μ in diameter. Host attached to substratum by the insertion of its proboscis.

Hosts. Hemiptera: several genera of aphides.

Habitat. Kittery, Maine; vicinity of Boston, Mass.; Europe.

It is with much hesitation that I have placed under the above name a species occurring in this country commonly, yet never very abundantly, on numerous aphides infesting the white birch, *Bidens* and other plants, in late summer and autumn, associated as a rule with other species which attack the same hosts. It is sometimes found also associated with *E. Aphidis* in greenhouses where it may be found during the winter months. It is very nearly related to *E. apiculata*, and, if not a variety of this species, forms a connecting link between it and *E. Grylli*. It differs from *E. apiculata* chiefly in the absence of rhizoids, which I have been unable to discover in fresh material after a careful search, as well as by the variability of its conidia which are rarely pointed as in *E. apiculata*, and vary from a form nearly spherical to one not separable from that of even the longer forms of *E. Grylli*. The species may be placed under *E. Planchoniana* only provisionally as may be understood from the following descriptions of the last named species by Cornu.

In speaking of the species,[1] Cornu says that the conidiophores, issuing from the body

[1] *l. c.* **A**.

of the aphides, "donnèrent naissance a une sphérule mucronée, remplie d'un plasma réfringent et au centre de laquelle apparaisait une spore en forme de toupie d'Allemagne. Dans l'air humide les sporanges furent lancés au loin," etc.: and in the only other place where I find the species characterized,[1] he says "Cette espèce parait characterisée par la production . . . de spores *ovoïdes oblongues*, sans sporanges, ou sporanges soudés à la spore" (the italics his). I am unable to reconcile these two descriptions or to determine whether the author here realizes what I consider to be the true morphology of the *Empusa* conidium. The phenomenon of the separation of the outer wall I have never seen in the round spored species of the "*Grylli*" type to which the present form belongs, and such a separation so exceptional in any case, that its occurrence as a characteristic of the general morphology of any species is highly improbable. A "sphérule mucronée" may refer to a conidium of the "*Muscae*" type; yet since the conidia are characterized as in the form "de toupie d'Allemagne" as well as "ovoïdes oblongues" this seems doubtful. The last expression perhaps refers to another species on aphides (the common *E. Aphidis*); yet any opinion concerning the form to which *E. Planchoniana* belongs is purely conjectural, since the above quotations which furnish all the published data concerning the species are not of such a nature as to render its determination possible.

Empusa papillata nov. sp.

Pl. 15, figs. 82–90.

Conidia broad-ovoid, evenly rounded, with a very large tongue-like slightly truncate papilla, clearly defined from the spore body. Average measurements $35 \times 50\mu$, maximum $50 \times 75\mu$. *Conidiophores* stout, simple. *Secondary conidia* like the primary. *Resting spores* azygospores (?), 45–55μ in diameter, spherical, slightly brownish. Host attached to substratum by a few large rhizoids, terminating in a sucker-like expansion.

Hosts. Diptera: several minute gnats.

Habitat. Mt. Washington, N. H.; Cullowhee, N. C.

I first noticed this species on the wet *Sphagnum* surrounding a spring in the locality known as the Alpine Garden on Mt. Washington, where it occurred in July and August (1886). I also found a small number of specimens on very minute gnats in the beds of mountain brooks at Cullowhee, in company with several other species, which occurred on moist logs and in similar situations. The conidia sometimes attain a size greater than any other *Empusa* known to me and are peculiar for their prominent tongue-like papillate base. They are formed usually in small numbers and are visible to the naked eye without difficulty. Like *E. apiculata*, this form is peculiar for its few powerful rhizoids which attach the host firmly to the moss or other substratum on which it rests. It differs from the last-mentioned species in its much larger conidia which are of a more ovoid shape, while it apparently lacks entirely the sharp point peculiar to the basal papilla of *E. apiculata*. It is not impossible that the form on *Culex* referred by Nowakowski to *E. Grylli* may be the present species; yet, as previously mentioned, I am inclined to think that he refers to the species I have called *E. conglomerata*. The two forms, *E. conglomerata* as above described and the present species, are, I think, quite distinct.

[1] *l. c.* B.

The resting spores of this species occurred in several specimens simultaneously with conidia, but were in every case too far advanced in their development to demonstrate their process of formation, which can hardly vary greatly from that of the nearly allied *E. apiculata*.

Empusa Caroliniana nov. sp.

Pl. 16, figs. 91–105.

Conidia ovoid, oblong or long elliptical, with rounded extremities, the base hardly separable from the apex; without large oil globules; measuring $10 \times 26\mu - 15 \times 45\mu$, average $14 \times 37\mu$. *Conidiophores* simple, barely projecting beyond the body of the host between the body segments and from the thorax; originating directly from rounded hyphal bodies. *Secondary conidia* like the primary. *Resting spores* (azygospores) spherical, hyaline, 37–55μ in diameter, average 45μ (?). Host attached to substratum by its legs.

Hosts. Diptera: imagines of *Tipula* sp.

Habitat. North Carolina.

This species is decidedly different from any form known to me and is easily recognized by its shapeless conidia which, although they are of the *Entomophthora* rather than *Empusa* type, are borne on conidiophores which are rarely branched within the body of the host and are perfectly simple at their extremities; the hyphae swelling directly to a basidium upon emerging. Specimens producing the fungus with the greatest luxuriance may therefore show little indication of its presence, and in dried material it is almost wholly invisible, the body segments closing over the basidia in shrinking. A single specimen only was taken at Cullowhee, while at Cranberry I procured a considerable amount of excellent material. The affected insects (a brown *Tipula* with mottled brown wings) were found in a small group of hemlocks among deciduous woods and occurred invariably hanging from the lower dead twigs, about which the extremities of their long legs were knotted in such a manner that it was impossible to disengage them. Several specimens contained only hyphal bodies and I was thus enabled to see the greatest possible development of conidiophores, by placing the *Tipulae* in a moist atmosphere. Other specimens produced both conidia and resting spores, although I was unable to make out the origin of the latter. As far as could be judged from the examination of material in which the process was already completed, it consisted in a budding from rounded hyphal bodies, but no satisfactory observation was possible in any case. The terminal and interstitial production of hyphal bodies (fig. 92) through the successive contraction of the contents of branching hyphae was frequently observed; but in other cases rounded hyphal bodies occurred, associated with resting spores, which were much larger than those represented in the figure and may have had a different origin.

Empusa (Triplosporium) Fresenii Nowakowski.

Pl. 16, figs. 106–140.

Empusa Fresenii, Nowakowski *l. c.* **B**, p. 171, Pl. XII, figs. 115–125. Schroeter *l. c.*, p. 222.

Conidia nearly spherical to short-ovoid, often with a short, truncate or commonly slightly papillate base; with granular contents; without large fat globules, and slightly smoky in color; $15 \times 18\mu$–$18 \times 20\mu$. *Conidiophores* simple, arising directly from small, spherical hyphal bodies of a yellowish color. *Cystidia* not observed. *Secondary conidia* of two kinds: the first like the primary, the second almond-shaped and borne obliquely on capillary conidiophores. *Resting spores*, zygospores, elliptical or subovoid, yellowish, becoming often smoky and opaque, formed by the conjugation of two small, spherical hyphal bodies by means of slender gametes, above the point of junction of which the spore rises as a bud; average measurements $30 \times 19\mu$. Host attached to substratum by the insertion of its proboscis.

Hosts. Hemiptera: *Aphis mali* and very many other aphides.

Habitat. Maine, Massachusetts, North Carolina, Europe.

The name adopted above for this interesting species is that used by Nowakowski in his Krakow paper[1], although, to avoid confusion, it should be mentioned that the same author in his review of this publication[2] uses the name "*Freseniana*" by an apparent oversight. The species is a very common one, having been found by Nowakowski on numerous aphides and also recorded by Schroeter as belonging to the Silesian flora. Although it has not been previously noticed in America, I have found it very common at Kittery, Maine, in the vicinity of Cambridge and also as far south as Cullowhee, N. C., where both the conidial and zygosporic forms occurred on an *Aphis* infesting *Solidago*. At Kittery, a black *Aphis* on poppy, as well as the common apple *Aphis*, was found attacked by *E. Fresenii* about the middle of June; and the last mentioned host contained abundant zygospores even at this early date. I have found the same species on aphides infesting *Bidens* and other plants about Cambridge as late in the season as the first week of October; but here no resting spores occurred. The formation of the resting spores, illustrated by the series of figures (127–140), has already been described in some detail (p. 148). As far as can be determined from alcoholic or dried material, the masses of protoplasm (figs. 106–108) from which the conjugating hyphal bodies are derived, have no proper wall, a circumstance which has been previously noted by Sorokin in connection with his *E. colorata*. Before reproduction commences, these protoplasmic masses become divided, rolling themselves into small, spherical hyphal bodies (fig. 127), which, when developing, certainly show the presence of a surrounding wall. This wall, during the process of conjugation, becomes considerably thickened, so that the two hyphal bodies remain attached to the spore in the form of bladder-like appendages which are tolerably persistent (figs. 135–138). The zygospores, which have been hitherto unknown, differ from all other described forms by their elliptical shape. In very mature specimens, they are sometimes almost black and opaque, though I am unable to say whether this is due to the absorption of coloring matter from the host; or whether, as seems more probable, the resting spores may not assume a smoky color, analogous to that of the conidia, which is deepened by age.

The conidia are readily distinguished by their small size and smoky tint, as well as by the peculiar almond-shaped secondary conidia of the second type, borne on slender,

[1] *l. c.* B. [2] Bot. Zeitung, XL, p. 561.

thread-like conidiophores, which may be seen produced from them abundantly in any preparation, the ordinary form of secondary conidia being of rare occurrence. The primary conidia possess more than usually refractive, homogeneous contents, in which are embedded numerous fine granules; and the thickness of the spore wall is noticeable as in the succeeding species, although in the present instance it is not indicated in figs. 110–116. The growth of the fungus is never luxuriant, and each spherical hyphal body, from its small size, can hardly give rise to more than one or two conidia.

As already mentioned, I have taken this and the succeeding species (*E. lageniformis*) as the types of a new sub-genus, *Triplosporium*, which will, I think, prove to have a generic value when further information has been obtained concerning the development of the last-named species.

Empusa (Triplosporium) lageniformis nov. sp.

Pl. 16, figs. 141–160.

Conidia slightly smoky, flask-shaped, with a truncate, hardly papillate base, rounded apex and evenly granular contents; average measurements $20 \times 35\mu$, maximum $30 \times 38\mu$. *Conidiophores* simple, or when young sometimes fasciculate or pseudodigitate; terminating by a weak, tapering basidium. *Cystidia* not observed. *Secondary conidia* like the primary, or almond-shaped and borne obliquely on capillary conidiophores. *Resting spores* unknown. Host attached to substratum by the insertion of its proboscis.

Hosts. Hemiptera: usually aphides on *Betula populifolia.*

Habitat. Maine, Massachusetts, North Carolina.

The discovery of the resting spores of this species is perhaps the most interesting fact that remains to be observed among American Empusae, owing to its undoubted affinity with *E. Fresenii.* The species being of larger dimensions than *E. Fresenii*, we may look for an instance of true conjugation which may be even more readily followed than in the last mentioned form. I have found only scattered examples of this species in single localities, although it is generally distributed in company with *E. occidentalis*, subsequently described. Both forms occur, as far as I have observed them in New England, only upon a large *Aphis* generally found in abundance on the white birch in August and September. Numerous specimens examined contain no signs of resting spores, producing only conidia which are similar to those of *E. Fresenii*, except as regards their larger size and somewhat peculiar shape. The single specimen collected at Cullowhee occurred on an *Aphis* infesting *Solidago*, so that it is probable that the disease could be readily propagated among greenhouse aphides, for example, and thus afford a means of observing its further development.

Empusa (Entomophthora) Lampyridarum nov. sp.

Pl. 17, figs. 161–172.

Conidia regular, ovoid; slightly tapering towards the apex; with an abrupt, broad, slightly papillate base; contents granular, without large oil globules. Measurements

$14 \times 30\mu - 20 \times 37\mu$, average $15 \times 35\mu$. *Conidiophores* digitate (?). *Secondary conidia* like the primary or more commonly long-cylindrical, rounded at either end, and borne *vertically* on capillary conidiophores. *Resting spores* unknown. Host attached to leaves, etc., by its mandibles.

Hosts. Coleoptera: imago of *Chauliognathus Pensylvanicus.*

Habitat. Cullowhee, N. C.

This interesting species was unfortunately not observed by me until a day or so before leaving Cullowhee, so that my material is limited to two specimens in fair condition, yet not sufficiently good to determine definitely the character of the conidiophores which, I have little doubt, are typically digitate. The specimens were allowed to discharge their conidia in a damp chamber so that the conidiophores were apparently exhausted by the operation; and those remaining were of the character represented in fig. 161. The secondary conidia of the second type are very peculiar, and separate the species at once from all others by their vertical position upon the conidiophore, as well as by their peculiar shape which is exactly that of a watermelon.

In the absence of more definite knowledge concerning the structure of the conidiophores, as well as from the lack of material containing resting spores, the affinities of the species are somewhat doubtful. It seems allied both to *Triplosporium* and to the *sphaerosperma* group of *Entomophthora;* but the type of development in its resting spores must be observed before this can be determined.

The melon-shaped secondary conidia are produced in great abundance, even in a fairly moist atmosphere, and in only one or two instances I observed a second form like the primary conidium in process of formation. In many cases, the more common secondary conidia were larger than the spores from which they were produced, and this, together with the apparent thinness of the spore wall, seems to indicate that they are not as resistent as is usually the case with secondary conidia when borne on capillary conidiophores. It will also be noticed that the secondary conidiophores are much less thread-like than is usually the case.

The affected beetles (fig. 172) were found firmly attached by their mandibles to grass or leaves in open fields; and, to judge from the number of heads that I observed in this position from which the bodies had been broken away, I should infer that the species had been not uncommon in the locality mentioned. The same beetle was abundant at Burbank, E. Tennessee, yet here I observed no specimens of the *Entomophthora.*

Empusa (Entomophthora) geometralis nov. sp.

Pl. 17, figs. 173–178.

Conidia short-elliptical to ovoid; $15–22\mu \times 10–12\mu$; contents finely granular, with a hyaline nuclear body. *Conidiophores* digitate, coalescing. *Cystidia* not observed. *Secondary conidia* like the primary, or long almond-shaped and borne obliquely on capillary conidiophores. *Resting spores* borne laterally or terminally on short hyphae as in *E. sphaerosperma;* spherical, colorless, average diameter 30μ, maximum, 35μ. Host attached to substratum by numerous rhizoids issuing from the abdomen at nearly the same point, and for the most part coalescing.

Hosts. Lepidoptera: imagines of geometrid moths (*Petrophora*, *Eupithecia*, *Thera*, etc.).

Habitat. Kittery, Maine.

This species was found during the month of September (1886) attacking geometrid moths of several species in or near pine woods, a favorite habitat of these insects. It is usually the habit of the host to rest with the abdomen curved upwards and, at one point of the under surface, resting on whatever object the moth may have lighted upon, usually a pine needle. At this point of contact, and, as far as I have observed, nowhere else, the rhizoids are produced in a tuft which thus fastens the insect by its abdomen. The rhizoids appear before death and I have found a small *Eupithecia* fluttering violently in its efforts to free itself from a pine needle to which the rhizoids had already become firmly attached (fig. 173). Although the specimens collected were found for the most part on the borders of pine (*P. strobus*) woods, several were noticed in other situations, as for instance, in a room used by me for collecting night moths by means of a lamp. Here several specimens of *Eupithecia*, thus attracted, were found fastened to the walls and window panes. The species was not studied while fresh and none of the dried specimens were in the proper condition for showing clearly the method by which the resting spores are formed. As far as could be seen, however, the process is similar to that described in *E. sphaerosperma*.

The conidia are peculiar and may be at once recognized by their short, thick form, which readily distinguishes them from those of the closely allied *E. sphaerosperma*.

Empusa (Entomophthora) occidentalis nov. sp.

Pl. 17, figs. 179–199.

Conidia of the *sphaerosperma* type, sometimes slightly fusiform, often tapering strongly towards the apex, with a broad, rounded, papillate base. Average measurements $35 \times 10\mu$, maximum $45 \times 12\mu$. Contents usually finely granular, sometimes with larger fatty bodies. *Conidiophores* irregularly digitate, coalescing in a white or slightly yellowish mass. *Cystidia* slender, slightly tapering. *Secondary conidia* like the primary, or long almond-shaped and borne obliquely on capillary conidiophores. *Resting spores*, azygospores or zygospores (?), borne laterally or terminally by budding from the hyphae; colorless, spherical, 20–35μ in diameter. Host attached to substratum by numerous rhizoids.

Hosts. Hemiptera: aphides on *Betula populifolia*.

Habitat. Maine, Massachusetts.

This is a well marked species of the *sphaerosperma* type, and occurs very commonly on the aphides which usually infest the common white birch in late August and in September. It generally is associated with the much rarer *E. lageniformis* which attacks the same host, and it may be found, in my experience, in almost any locality where the white birch grows. The conidia are chiefly noticeable from such forms as are represented by figs. 183 and 184 which strike the eye at once in examining a preparation. The contents of the conidia are usually finely granular with a central nuclear body (figs.

185–189); but sometimes contain fatty globules of considerable size. The resting spores often occur in specimens also producing conidia, and are commonly formed by lateral budding from short hyphae in an apparently non-sexual fashion; but numerous instances occur, as in *E. sphaerosperma*, where the budding is associated with a partition, as in figs. 196, 198–199, which may perhaps indicate a sexual process. In a few cases spores developing from long hyphae growing in the legs seemed to result from a process which may with safety, I think, be considered a form of conjugation (fig. 197).

The species has little that is peculiar in its structure and is only interesting as being another example of the strongly marked *sphaerosperma* type.

Empusa (Entomophthora) sphaerosperma (Fres.).

Pl. 17, figs. 200–219.

Entomophthora sphaerosperma, Fresenius *l. c.* **A**, p. 883; *l. c.* **B**, p. 207, Taf. IX, figs. 68–78. Sorokin *l. c.* **C**, p. 220, figs. 579–81, 586–90, 632–33, 654. Schroeter *l. c.*, p. 223.

Tarichium sphaerospermum, Cohn *l. c.* **B**, p. 84.

Empusa radicans, Brefeld *l. c.* **A**; *l. c.* **B**, p. 14, Taf. I-II.

Entomophthora radicans, Brefeld *l. c.* **C**; *l. c.* **D**. Nowakowski *l. c.* **A**; *l. c.* **B**, p. 165, Taf. X, figs. 63–67, Taf. XI, fig. 71.

Entomophthora Phytonomi, Arthur *l. c.* **A**; *l. c.* **B**.

Conidia long-elliptical to nearly cylindrical; papillate at base and tapering very slightly near the rounded apex; 15–26μ × 5–8μ, average 20 × 5.5μ; usually with a fine granular contents and a central oval nuclear body. *Conidiophores* much branched and confluent over the body of the host, forming usually a mass the upper surface of which is flattened. *Conidiophores* digitate. Color of the fungus as a whole white, varying to bright pea green. *Cystidia* slender, tapering, not abundant. *Secondary conidia* like the primary, or long almond-shaped and borne on a capillary conidiophore. *Resting spores*, azygospores or zygospores (?), borne laterally or terminally from hyphae; 20–35μ, average 25μ; spherical, hyaline or very slightly yellowish. Host attached to substratum by rhizoids.

Hosts. Lepidoptera: imago of *Colias philodice;* larva of *Pieris.* Hymenoptera: Ichneumonidae of several genera and species, a small bee (near *Halictus*). Diptera: imago of *Musca domestica* (Brefeld), *Musca sp.* (Roan Mt., Thaxter); numerous small species belonging to the Culicidae, Mycetophilidae, Tipulidae and other families. Coleoptera: larva of *Phytonomus punctatus;* imago of one of the Lampyridae. Hemiptera: *Aphis sp.*; several species of *Typhlocyba* (leaf hoppers), larvae, pupae and imagines. Neuroptera: imago of *Limnophilus* (?) (Schneider). Thripidae: larvae, pupae and imagines of a species of *Thrips* on *Solidago.*

Habitat. Maine, New Hampshire, Massachusetts, New York, North Carolina, Europe.

It is unnecessary to remark that this species is peculiar for the great diversity of its hosts which include all insect orders, excepting only the Orthoptera. It is an extremely common form, probably from this reason, and often produces epidemics of considerable

proportions. It was first reported from this country by Mr. J. C. Arthur who describes it as *Entomophthora Phytonomi* n. s., having found it destroying the clover weevil (*Phytonomus punctatus*) in great numbers in the vicinity of Geneva, N. Y. The affected larvae, just before death, crawl up blades of grass, etc., and curling themselves around them near the summit are attached by the rhizoids in this position. Material of the *Phytonomus* form received by me from Professor Riley, which was collected, I believe, by Professor Lintner at Albany, N. Y., shows no sufficient differences which can separate it from the same form on other hosts, although the average measurements of the conidia are very slightly larger than in the majority of cases, the maximum length given by Arthur being 28μ, while as a rule I have seldom found it more than 25μ. The shape of the spores is identical with that which characterizes the other forms and is similar to the published figures of *E. sphaerosperma* to which all the forms occurring on the hosts above enumerated should, I feel confident, be referred.

In my own experience, I have observed two epidemics caused by this species: one among certain small flies in a wood near marshy ground at Kittery, Me., where the hosts occurred in considerable numbers fixed by the fungus on the under side of the lower leaves, a few feet from the ground. The second instance occurred in two orchards in the same locality where the hundreds of the previously mentioned epidemic were replaced by tens of thousands, the host in this instance being the leaf-hopper (*Typhlocyba mali* and *rosae*), a pest only too well known to cultivators of roses. Having first observed it in some abundance on roses in a garden, I was led to make an examination of adjacent apple orchards, and found the lower branches of the trees literally covered with the affected hosts, a dozen or more being often fastened to a single leaf. Unfortunately, I was too late, and in almost all cases the specimens had discharged their spores, while no more hosts remained for infection. A few, however, were still producing conidia, and it occurred to me to endeavor to infect from them the larvae of *Pieris*, which is the common European host of this species. For this purpose I placed a small number of young larvae in the bottom of a jelly tumbler, fixing the infected hosts above them as previously described. This was on Sept. 10 (1886); on Sept. 16, the majority had prepared to pupate, the larvae having been too far advanced when infected. One larva, however, on the evening of the sixteenth, was found dead and attached to the leaf on which it had been feeding by powerful rhizoids which issued from the region of the prolegs. This larva was not disturbed for twenty-four hours, in the hope that conidiophores might make their appearance, but none appeared, and the insect became slightly collapsed. Upon examination, it was found to contain numerous, spherical resting spores, about 25μ in diameter, the origin of which could not be seen, all traces of hyphae having disappeared owing to a partial decomposition of the contents of the caterpillar which also contained several larvae of *Pteromalus*. This fact surprised me greatly, since, in his infection experiments, Brefeld states that no result was produced when spores were sown on larvae thus infested. A double parasitism was also found in my experiments with *E. Grylli* previously mentioned, in which the larvae of certain insect parasites issued from several caterpillars thickly covered by conidiophores. The remaining larvae in the present experiment died with *Pteromalus* or pupated within a day or so. Several died from *Pteromalus* after pupation, and the remainder, three or four in number, died before

or after pupation and were found to contain irregular bodies resembling hyphal bodies, but often without apparent walls and associated with a general fatty degeneration of the whole contents of the pupa. At this date (Sept. 17) it was only possible to procure very poor material for infecting a fresh set of *Pieris* larvae, and although much younger larvae were selected than in the previous experiment, no results were obtained; the caterpillars upon reaching maturity either dying from insect parasites or pupating.

Although these experiments by themselves are not by any means convincing, the infection of even a single *Pieris* larva from a host so totally different, and under circumstances such as I have described, when taken in connection with the structural similarity existing between the American and European forms, furnishes in my opinion sufficient ground for considering them as belonging to a single species.

The occurrence of this species on a butterfly (*Colias philodice*), fig. 200, is also an interesting fact; the specimen in question, which was found on the ground in a pasture at Kittery, being, I believe, the first recorded instance of this nature. This is also I think, the only species that has been found to attack hymenopterous imagos, on which it very commonly occurs; a fact that might be of interest to bee-raisers, should the fungus develop a local fondness for bees. In this connection it may be noted, however, that several hives of bees placed under the trees in the apple orchards above mentioned, showed no signs of any entomophthorous disease.

The species probably has a very wide geographical range, and although in North Carolina I have found it less common than in New England, it occurred in some quantities on a fly, somewhat smaller than *Musca domestica*, which I found fixed to the under sides of the leaves in *Rhododendron* thickets on the summit of Roan Mountain. On Mt. Washington, N. H., I have found it infesting flies, ichneumons, and a minute *Thrips* which it destroyed in great numbers. This occurrence upon *Thrips* is interesting as illustrating the omnivorous character of the parasite. Krasilstchik, in his list of insect hosts attacked by fungi, gives *Thrips* as the host of an undetermined species of *Entomophthora* which is, I believe, the only other recorded instance of this insect as an *Empusa* host. The infested larvae, pupae and imagines of this insect, as they occurred on Mt. Washington, were hardly visible without a hand lens. Both conidia and resting spores occurred in this instance; the former somewhat smaller and more irregular than in the case of hosts whose size admits of a more luxuriant growth of hyphae, yet differing but little from the usual type.

The general appearance of the fungus in this, as well as in the succeeding species, when it is well developed on its smaller hosts, is almost always sufficiently peculiar to distinguish it from other Empusae. The whole mass of conidiophores coalesces over the body often leaving only the middle of the thorax uncovered; but instead of presenting the rounded form usual in other Empusae, the upper surface has a flattened appearance, and is the only portion from which conidia are discharged. This is due to an oblique tendency observable in the growth of the main hyphae, as is indicated in fig. 202, the left hand portion in the figure corresponding to the outer part of the whole mass. The basidia thus have a general tendency to point upwards instead of in all directions as is usually the case. The occurrence of specimens in which the mass of conidiophores is colored green or greenish is not common, and the color fades on drying: but in two cases in the epidemic among leaf hoppers just mentioned, I found specimens in which it

was colored a vivid pea green, a circumstance that can hardly be due to any coloring matter from the host, which is of a pale yellowish tint. A similar coloring will be noticed presently under *E. dipterigena*.

The formation of the resting spores in this species has already been mentioned (p. 147). The instances figured (figs. 214–217) were taken from two leaf hoppers, the only specimens that I have examined in which the development of the spores was at exactly the proper point for observing their origin. The differences apparent between this process and that figured by Brefeld[1] are, in my opinion, merely the result of the difference existing between the conditions present in either case; the totally dissimilar nature of the host being in itself a sufficient explanation. It should be noticed also that in the legs of these same specimens the hyphae were long and continuous, and, although no resting spores had begun to develop in them, an occasional anastomosis was apparent; while the same is true of the preceding species (*E. occidentalis*) in which resting spores were observed in a similar situation in connection with hyphae which showed anastomoses here and there.

Empusa (Entomophthora) Aphidis Hoffman.

Pl. 18, figs. 220–240.

Entomophthora Aphidis, Hoffman in Fresenius *l. c.* **B**, p. 208, figs. 59–67. Winter *l. c.* Sorokin *l. c.* **C**, p. 213, figs. 593–594, 634; *l. c.* **D**, p. 60, plate II, figs. 14–18. Nowakowski *l. c.* **B**, p. 164, figs. 59–62.

Tarichium Aphidis, Cohn *l. c.* **B**, p. 84.

Entomophthora ferruginea, Phillips *l. c.*, p. 4, plate III, figs. 1–13.

Conidia ovoid to elliptical or subfusiform; commonly asymmetrical and very variable; with papillate base and containing numerous oil globules. Average measurements $25 \times 12\mu$, maximum $16 \times 40\mu$. *Conidiophores* digitate, often simple. Hyphal bodies spherical, germinating in all directions and giving rise to numerous contorted hyphae which grow into conidiophores. *Cystidia* rather slender and tapering at their extremities. *Secondary conidia* like the primary, or short ovoid with a single large oil globule. *Resting spores* "spherical, $33–45\mu$ in diameter and borne terminally or laterally on hyphae" (Fresenius and Sorokin). Host attached to substratum by rhizoids, few in number, and usually terminating in a disc-like expansion.

Hosts. Hemiptera: Aphides of numerous genera.

Habitat. Maine, New Hampshire, Massachusetts, N. Carolina, Washington, D. C., Europe.

It is of course impossible to determine whether the description of Fresenius[2] really refers to this species or to other forms found upon aphides and producing similar resting spores; yet there can be no doubt that the conidia first described by Winter[3] and subsequently described and figured by Nowakowski are identical with those of the form above described. Although I have not myself observed the resting spores of this species, they are described by Winter and Sorokin as spherical, so that the assumption is justified that in the present instance we are dealing with the true *E. Aphidis*, which must

[1] *l. c.* **D**. [2] *l. c.* **B**. [3] *l. c.*

otherwise be distributed among at least four other species having spherical resting spores and growing upon aphides, namely, *E. sphaerosperma*, *E. occidentalis*, *E. Planchoniana* and the form under consideration. I have, it will be noticed, placed *E. ferruginea* as a synonym of this species, although Mr. Phillips states that his species, in the opinion of Mr. Cook, is a distinct form, as shown by a comparison with authentic specimens of *E. Aphidis*. The figures and descriptions of *E. ferruginea*, however, as far as I can judge, point to the present species; and moreover the exsiccati specimens of *E. Aphidis* are unreliable, the two numbers that I have examined[1] containing in the one instance nothing whatever, and in the other *E. Fresenii*, a species which cannot be confounded in any way with *E. Aphidis* on account of its peculiar resting spores.

Although this species (*E. Aphidis*) has not, to my knowledge, been previously reported from the United States it is, with the exception of *E. Muscae* and perhaps *E. Grylli*, the commonest of all the Empusae; occurring abundantly in the localities above mentioned. It was first called to my notice by Dr. George Dimmock who noticed it in a greenhouse in Cambridge during the winter of 1886. In this situation it acted as a decided check to the multiplication of the aphides, yet did not spread with sufficient rapidity to render "smoking" in the greenhouse unnecessary. At Kittery I have found it on numerous genera of aphides and especially destructive to the forms which injure the hop. In one case I observed a large hop vine some twenty feet high completely covered with aphides which were killed off by this fungus in about two weeks; the affected hosts being fastened to the under sides of the leaves, and to the younger shoots in vast numbers. The destruction of colonies of *Aphis* by this species or by *E. Fresenii* seems to be the rule rather than the exception, and is at least of very common occurrence. An instance of the kind was called to my attention during the second week in June of the past year (1887) by Mr. L. O. Howard, who showed me great quantities of aphides dying of the disease on clover near the agricultural department buildings in Washington. The probable agency of ants in spreading these epidemics is worthy of notice as well as that of night moths, especially *Noctuidae*, which, as well as ants, are often attracted in great numbers by the sweet secretion of the aphides.

Despite the abundance of the conidial form, I have never obtained a single specimen of the resting spores that I have been able to discover among my material. The conidial form is chiefly of interest from the peculiar "germination" of the hyphal bodies represented in fig. 239, and consisting in the production, from a central cell with a highly refractive contents, of a mass of hyphae growing from it in all directions, and subsequently giving rise to the conidiophores. This at least is the usual derivation of the mass of contorted and branched hyphae which may be found filling the aphides just before the external appearance of the conidiophores. The number of these cells or hyphal bodies is small, as may be inferred from the enormous number of hyphae which each produces, and their origin is a question which I have been unable to settle from actual observation; although in a few cases I have found large hyphae at a less advanced stage of the development of the fungus, the contents of which were collected terminally or interstitially into rounded masses which may have represented the hyphal bodies in question.

The conidia are noticeable from their considerable range of variation, both in size and

[1] Myc. Univ. No. 1916; Herb. Myc. No. 768.

shape. The conidiophores are white in the mass, often tinged with yellowish or flesh color from the coloring matter of the host, which usually assumes a pale brick-red tint at or just before death. This change of color is, however, common to most aphides attacked by Empusae and cannot be considered distinctive of any species. In one instance I have found a form, apparently this species, on a large bug (one of the *Corisiae?*); but, unless the species subsequently described as *E. dipterigena* proves to be the same fungus, there is little variation from the usual host.

Empusa (Entomophthora) dipterigena nov. sp.

Pl. 18, figs. 241–250.

Conidia variable in shape, ovoid to oblong or subfusiform, with a papillate base, often bent to one side, and containing numerous large oil globules; average measurements 11×22μ, maximum 15×30μ. *Conidiophores* digitate coalescing over the body of the host in a clear white, very rarely bright pea green mass. *Cystidia* slender, tapering toward the apex. *Secondary conidia* like the primary or broad-ovoid. *Resting spores* (zygospores?) produced *externally* in grape-like clusters; spherical, hyaline, 20–40μ in diameter. Host attached to substratum by rhizoids; few in number, large, with a disc-like terminal expansion.

Hosts. Diptera: small Tipulae; other small flies or gnats belonging especially to the Mycetophilidae.

Habitat. Maine, New Hampshire, Massachusetts, North Carolina.

Before discovering specimens of this species producing both the conidia and resting spores simultaneously, I was inclined to regard it as a mere variety of *E. Aphidis;* but the peculiar external production of the resting spores, taken with its generally smaller measurements and quite different host, serves sufficiently to distinguish it. It is nearly allied to *E. ovispora* and *E. echinospora*, but separable at once from the first by its slender tapering cystidia, and from the second by its smooth resting spores. From *E. Americana* it is separable by its smaller, often subfusiform conidia, as well as by the presence of cystidia, its general habit and peculiar rhizoids.

None of the specimens found contained resting spores at a sufficiently early stage of their development to show the nature of their origin. The youngest examples, in which the spore contents were still granular, indicated a tendency to produce distinctly grape-like clusters, and in all cases the spores were external. The species is not uncommon, occurring only on the under side of leaves in woods or thickets, and was first noticed on Mt. Washington in late August, at the head of Tuckerman's ravine, and subsequently collected in swamps about Kittery, Maine, in small numbers. In North Carolina, it was more common in similar situations, both forms of spores occurring not infrequently.

I have placed the *E. rimosa* of Schroeter[1] as a doubtful synonym of this form, with which his description coincides with little variation. Schroeter's species is certainly not the *E. rimosa* of Sorokin, the spores of which belong to a very different type.

[1] *l. c.*

Empusa (Entomophthora) virescens nov. sp.

Pl. 18, figs. 251–261.

Conidia ovoid to oblong, of irregular shape; with bluntly rounded base and apex, the former often hardly papillate and not well distinguished from the apex; color greenish yellow in dried material; containing numerous small, irregular, often rod-like fat bodies; measurements $10\times20\mu$–$16\times36\mu$, average $14\times30\mu$. *Conidiophores* digitate, arising indirectly from spherical hyphal bodies which germinate in all directions, giving rise to very numerous hyphae which subsequently become conidiophores. *Cystidia* not observed. *Secondary conidia* like the primary. Resting spores unknown. Host attached to substratum by rhizoids?

Hosts. Lepidoptera: larvae of *Agrotis fennica.*

Habitat. Ottawa, Ontario (Mr. Fletcher).

The specimens from which the above description was taken were received by Professor Farlow from Mr. J. Fletcher, Dominion entomologist, who writes concerning them as follows:—"In the spring of 1884 from May 15 until the end of the first week in June, all the gardens and fields in the district around Ottawa were severely attacked by the larvae of *Agrotis fennica.* The disease of which you have a specimen was first observed about the 22nd of May, and was extremely virulent. Dead larvae were to be found in all directions; on stone walls, on fences and particularly on the tops of stems of grasses. They were also vigorously assailed by Tachinidae and Carabidae. The *Entomophthora*, however, was undoubtedly *the* influence which brought this insect down again to its normal rare occurrence at Ottawa." The specimens received were black and shrivelled, the fungus appearing as a greenish yellow coating, emerging in small tufts, which, in the more mature specimens, appear to have coalesced over the body. The conidia appear also greenish yellow in the mass, and are recognized by their general shapelessness and rounded extremities, as well as by the numerous small fatty bodies of a crystalline appearance which characterize the spore contents. I have placed this species near *E. Aphidis* from the structural similarity indicated by the peculiar germination of the hyphal bodies already described in the last-named form; but the conidia seem to be of a different type.

It should be noted that the host of this species is closely allied to that of *E. megasperma* of Cohn which also occurs upon an *Agrotis* larva. Mr. Fletcher writes me that he has not observed a single specimen of the fungus since the date above mentioned, and as the material originally sent contained only conidia I am unable to give any information concerning the resting spores. The conidia of *E. megasperma* are unknown, nor has the species been observed to my knowledge since it was described by Cohn.[2] The resting spores of *E. megasperma* are fortunately an exception to the general rule, being readily recognized by their dark brown, reticulate epispore, so that the question concerning the identity of the present form with Cohn's species can be settled beyond a doubt as soon as the resting spores of the one or the conidia of the other become known.

[1] *l. c.* B.

Empusa (Entomophthora) Americana nov. sp.

Pl. 18, figs. 262–273.

Conidia long-ovoid, with a broad evenly rounded apex; tapering for some distance to a papillate base often slightly bent to one side. Within the spore are usually numerous fatty bodies often very regular in size and shape. Average measurements 28–30$\mu \times 14\mu$, maximum $35 \times 15\mu$. *Conidiophores* regularly digitate, arising from large, irregular, roundish hyphal bodies, and coalescing over the host in a mat-like covering which becomes slightly rust colored on exposure. *Cystidia* absent. *Secondary conidia* like the primary. *Resting spores*, colorless, hyaline, spherical; average diameter 38–45μ, maximum 50μ. Process of formation not satisfactorily observed. Host attached to substratum by numerous filamentous rhizoids, without terminal root-like expansions; forming an even mat-like attachment continuous around the abdomen of the host.

Hosts. Diptera: *Musca domestica*, *M. comitoria*, *Lucilia Caesar*, and numerous other large flies.

Habitat. New England and North Carolina.

This common species is frequently met with from June to October on the borders of woods, near brooks or in shrubbery about houses. The host is generally found fixed to the under, rarely on the upper, side of leaves or on bare twigs, a few feet from the ground. It can readily be distinguished by its general habit from any species known to me with the exception of *E. echinospora;* since the rhizoids instead of growing out in the form of numerous scattered threads are developed in an even layer around the hosts' body forming, with the conidiophores, a continuous mat-like covering which becomes often dark rust colored on exposure to the weather. The mass of conidiophores is at first pure white, and in a moist chamber grows with great luxuriance.

The conidia are almost identical in appearance with those figured by Nowakowski as belonging to *E. orispora* and the measurements are very nearly the same. *E. orispora* is, however, at once separated from the present species by its peculiar cystidia which resemble those belonging to *E. sepulchralis* (fig. 306). In the present species, I believe there are no cystidia whatever, and I have looked in vain for anything remotely resembling them. Whether the type of conjugation found by Nowakowski in *E. orispora* exists also in the present species, I am unable to say, since in all cases in which I have found resting spores, the latter were mature and no trace of their method of production was visible. *E. Americana* is also closely allied to *E. muscivora* of Schroeter which seems to be identical with *E. Calliphorae* of Giard. The resting spores in both these instances are described as chestnut or deep chestnut brown; and since the material of both seems to have been abundant, I have no hesitation in separating them from our species in which the spores are always perfectly hyaline. They occur not infrequently in connection with the conidia, and my material is sufficiently large to demonstrate the invariability of their color or lack of color. In North Carolina the species was of rarer occurrence than in New England, and I obtained but few specimens on shrubs in open woods or on twigs of hemlock. It has been taken also by Professor Farlow and Mr. Miyabe at Woods Holl, Mass., and a specimen from New Hampshire which I have not examined

microscopically is in Dr. Hagen's collection of entomogenous fungi. I have collected it frequently at Kittery and in the vicinity of Boston, and it has been sent to me from Jaffrey, N. H.

Empusa (Entomophthora) montana nov. sp.

Pl. 18, figs. 274–285.

Conidia, ovoid to turbinate, usually tapering from a broadly rounded apex to a somewhat attenuated, slightly pointed base, containing numerous large oil globules and measuring $11 \times 18\mu$–$15 \times 25\mu$. *Conidiophores* digitate, coalescing over the host in a livid white mass and arising directly from rounded hyphal bodies. *Cystidia* tapering or rounded at the apex, larger than the conidiophores. *Secondary conidia* like the primary or short ovoid. *Resting spores* unknown. Host attached to substratum by numerous rhizoids.

Hosts. Diptera: a minute gnat, apparently *Chironomus* sp.

Habitat. Alpine summit of Mt. Washington, N. H.

This small species was found late in August, 1886, in great abundance on a small gnat common about one of the brooks running into the "Lake of the Clouds" on Mt. Washington; several hundreds of specimens being obtained from the wet *Sphagnum* bordering the brook. I have observed it in no other locality, even on Mt. Washington, although thorough search was made in similar localities in other parts of the mountain. The species presents no peculiarities of interest beyond the shape and size of its conidia which are readily distinguished by their usually pointed base and broad apex which give them the appearance of a long top.

Empusa (Entomophthora) echinospora nov. sp.

Pl. 19, figs. 286–305.

Conidia ovoid, tapering to a papillate base; usually nearly symmetrical; 20–25×10–14μ; containing one or more large oil globules. *Conidiophores* digitate, coalescing into a mat-like covering which turns rust colored on exposure. *Cystidia* not observed. *Secondary conidia* like the primary or varying only slightly. *Resting spores*, zygospores, spherical 30–40μ in diameter, the exospore spinose; commonly produced externally as well as internally, and in the former case held slightly, after maturity, by a delicate mesh of hyphae. Host attached to substratum by rhizoids, coalescent around the abdomen in the conidial form.

Host. Diptera: imago of *Sapromyza longipennis* and rarely other smaller Diptera.

Habitat. Maine, New Hampshire, North Carolina.

A single specimen of this interesting species containing both resting spores and conidia, together with several examples that were useless from exposure, were found in August, 1886, among the alders at the head of Tuckerman's ravine, Mt. Washington, on the pretty yellow-winged fly that appears to be its almost invariable host. The conidia so nearly resembled those of *E. Americana* and *E. dipterigena* that it was only by accident that I examined the specimen a second time after having placed it with my material of these

species. Having discovered the peculiarity of its resting spores, I looked for it with some care in North Carolina during the succeeding summer and was rewarded by finding the same host repeatedly infested by the same fungus. In Carolina it occurred almost invariably on the under side of leaves especially of *Impatiens* growing beside brooks in the woods. The conidial form was extremely rare, but of the resting condition I procured some dozens of specimens. In very many cases the resting spores are produced wholly, or more commonly partially, outside the body of the host, having originated from hyphae (fig. 297) which emerge after the manner of conidiophores, and subsequently conjugate as shown in figures 298–302. Certain of these hyphae are seen to project some distance beyond the rest (fig. 297) and ultimately form a delicate web which serves to hold the mass of spores to some extent. None of my material was sufficiently good clearly to show conjugation within the body of the host, and the hyphae were so evanescent and filled with such large globules of fat that points of conjugation could hardly be made out in the confused mass. The spines develop more rapidly within the body than without and as a result of their formation the abdomen becomes greatly inflated. This inflated appearance together with the peculiarity of the host are sufficient to distinguish the species in collecting, and it is a singular fact that this particular species of fly (*Sapromyza*), even in situations where *E. dipterigena* was common and *E. Americana* not infrequent, never appeared to be attacked by any other *Empusa*. The spinose character of the spore is due to elevations of the rather thin-walled epispore only, and is thus readily obliterated by long exposure or transformed into a roughness of the surface. The epispore may also be easily removed by pressure of the cover-glass upon it, disclosing within a spherical resting spore of the usual type. The species is very nearly allied to *E. dipterigena*, the conidia of the two being hardly separable in some cases. The papilla is, as a rule, broader in *E. echinospora* and the spores seldom tend to become fusiform. The type also represented in figures 243–244, which is characteristic of groups of conidia in the former species, is wholly wanting in the latter as far as I have observed.

Empusa (Entomophthora) sepulchralis nov. sp.

Pl. 19, figs. 306–326.

Conidia long-ovoid to long-elliptical or subfusiform, rounded at the apex and with a papillate base commonly bent to one side; hyaline, with numerous large oil globules; measurements 35–48 × 10–15μ, maximum 15 × 55μ. *Conidiophores* digitate, arising from large (60μ diam.) spherical hyphal bodies and coalescing over the body of the host in a clear white mass. *Cystidia* very large (70–90μ in diameter), slightly expanded or commonly becoming branched at their apices. *Secondary conidia* like the primary or short-ovoid. *Resting spores*, zygospores, spherical, hyaline, 35–50μ in diameter; formed as the result of a *Spirogyra*-like conjugation between two hyphae and arising by budding from the gametes. Host attached to substratum by numerous rhizoids.

Hosts. Diptera: imagines of Tipulidae.

Habitat. North Carolina, E. Tennessee.

This fine species was collected at Cullowhee, Cranberry and Burbank from June 20

to Sept. 5 of the past summer (1887), occurring commonly on the largest Tipulae, which were often found in considerable numbers adhering to wet logs or similar objects along the small brooks, so constantly met with in the Carolina mountains. Localities most attractive to the Tipulidae were naturally the most productive of the *Entomophthora* and, in situations where the brooks were obstructed by fallen trees or roots over which they partially flowed, a dozen or more often occurred side by side. A plentiful supply of moisture seems always necessary for the development of the fungus, which is only found on surfaces saturated with water. This circumstance results in a very luxuriant growth of the conidiophores which makes this species the most conspicuous of any form on Diptera known to me. Although the abdomen of the host is usually narrow and not more than a few mm. broad, the conidiophores, after bursting through the integument about the thorax and between the segments, become confluent and spread to some distance on either side of the body forming a clear white mass of considerable dimensions. The effect thus produced is decidedly ghost-like, especially when a number of Tipulidae are seen in this condition beneath a shaded log, and has suggested the specific name.

The species is remarkable from its formation of true zygospores in a fashion similar to that discovered by Nowakowski in his *E. orispora*, *E. conica* and *E. curvispora*. I was unable to determine that the zygospores were formed from the same hyphae which bear the conidia, as stated by Nowakowski in the species above mentioned, and it seems more probable from my observations that certain of the hyphal bodies develop conjugating hyphae, while others develop conidiophores. I was unable to satisfy myself on this point, since cultivation of the chlamydospores in water produced only conidia; and, in specimens producing zygospores, the hyphae were invariably too much broken up to allow of any definite conclusion in this respect. I found no instances in which zygospores alone were formed and usually the number was comparatively small. They were, however, almost invariably present in greater or less abundance in the considerable number of specimens examined; yet only in a small number of cases did I find them in the early stages of formation. This is apparently due to the great rapidity of the process after it has once begun, since, in several instances, specimens in which no zygosporic formation was visible when first examined, contained perfectly formed zygospores after the lapse of a few hours. The singularly large cystidia are very noticeable and readily seen with the naked eye, the drop of moisture which, as a rule, they bear at their apices giving them the appearance of conidiophores with single apical spores of unprecedented dimensions. The species is allied to *E. ovispora* and *E. conica* as well as *E. rhizospora* with all of which it agrees exactly in the origin of its zygospores. It is perhaps most nearly allied to *E. ovispora* from which, however, it differs by its much larger and differently shaped conidia, which although subject to some variation in size and shape, especially when developed in situations where the supply of moisture is insufficient, are yet tolerably constant at from 40 to 50μ in length. The ease with which the outer wall becomes separated in this species is noticeable in fresh material, and in several instances I observed this phenomenon carried to such an extent that the spore proper floated free within the inflated and spherical mother cell (fig. 321).

It should be noted that the occurrence of this species although common was decidedly local, and in no instance did I find it in company with allied forms at even a short distance from the water.

Empusa (Entomophthora) variabilis nov. sp.

Pl. 20, figs. 327–343.

Conidia usually varying according to the period of their discharge, those first formed being ovoid, short and stout, with a papillate base and broadly rounded apex and measuring about $15 \times 11\mu$. Those formed later are much more elongate, either shaped like a short straight club or strongly curved, and measure $18–30 \times 7–9\mu$, average $25 \times 8\mu$. *Conidiophores* digitate, having in the mass as a rule a distinctly olive tint. *Cystidia* in small numbers, slightly tapering, larger than the conidiophores. *Secondary conidia* like the primary, of two general types. *Resting spores* unknown. Host attached to substratum by numerous rhizoids.

Hosts. Diptera: minute gnats of various genera.

Habitat. North Carolina.

I have found this small species pretty generally associated with *E. conica* in Carolina especially at Cullowhee, where it occurred not uncommonly in the beds of wood-brooks and was found by turning over stones or wet pieces of wood in these situations. It seldom occurs, in any abundance in one locality, and is very difficult to find from the minute size of the insects which it attacks: yet it is almost always recognizable by the olive color of the conidiophores which, though not invariable, usually affords a ready means of separating it from other species with which it may be associated. I know no other species in which a peculiarity in the tint of the conidiophores as a mass serves as a distinguishing character, although the occurrence of a bright green specimen has been noted in *E. sphaerosperma* and *E. dipterigena*. In these cases, however, the colored forms are rare exceptions. The variation of the primary conidia from short-ovoid (fig. 343) to straight or curved forms several times longer than broad (figs. 329–342) is a noticeable feature in this species, and led me at first to separate my material into two sets which I considered distinct species. By allowing the discharge of spores to continue for a longer time I have, however, repeatedly seen the longer form replace the shorter one, and I think there can be no doubt of their specific identity. The secondary conidia of the second type are nowise different from these first formed primary conidia.

The resting spores, I feel confident, I found in one instance; the insect containing them being associated with others bearing conidia. The specimen, which has unfortunately been lost, had produced no conidia so that I was unable to verify this opinion. From memory I can only say that the spores were small in size, decidedly brownish and held together by the hyphae from which they were formed. These hyphae, as in the nearly allied *E. rhizospora*, seemed somewhat indurated: but they were formed internally, and did not produce the rhizoid-like outgrowths which characterize the last named species. The resemblance of this form to *E. curvispora* should be noted, many of the spores closely resembling those figured by Nowakowski as belonging to this species.

Empusa (Entomophthora) rhizospora nov. sp.

Pl. 20, figs. 347–348.

Conidia, in form, like a straight short club, varying to almost crescent-shaped; very variable, tapering more or less at either extremity, the basal portion of the spore neck-like

and bearing the rounded papilla of attachment; contents with large fat globules; average measurements 30–35 × 8–10μ, maximum length 42μ. *Conidiophores* digitate, coalescing in a livid white mass over the insect. *Cystidia* large, not numerous, slightly tapering. *Secondary conidia* like the primary, or spherical with an abrupt, delicate papillate base. *Resting spores*, zygospores, spherical, 40–60μ, with brownish epispore; budding from *Spirogyra*-like gametes and subsequently surrounded by rhizoid-like outgrowths which are closely applied to the spore and originate at its base. The hyphae producing zygospores are always *external* and subsequently become thickened and horny, turning dark chocolate brown and holding the spores in a spongy mass. Host attached to substratum by numerous rhizoids.

Hosts. Neuroptera: several genera of Phryganeidae (imagines).

Habitat. Kittery, Maine; and North Carolina.

This interesting form was first observed by me at Kittery, where I found one or two specimens producing only resting spores, under boards or logs in swampy situations. From the peculiarities of its spores and their external formation, I was inclined at first to consider it as the type of a different genus; since none of these specimens were in sufficiently good condition to demonstrate the method by which the spores were formed and the hyphae had already become brown and indurated. In North Carolina, I found both the conidial and the zygosporic form very common, both kinds of spores often appearing on the same specimen. The affected hosts were not, as in the preceding species with which it is commonly associated, exposed in open sight; but, in accordance with the hiding habit of the caddis flies (Phryganeidae), were found concealed under saturated logs or very commonly under stones, partially exposed in the bed of shallow wood streams, or in swampy places in woods. The larvae were also common in the same situations, but I never observed that they were attacked by the fungus.

Although a very large number of specimens were examined I only found a very few in which the process of conjugation was visible, and even in two instances where it had not begun at sundown, I found it completed during the forenoon of the following day so that its details could not be seen. The process is thus, as in the preceding species, a very rapid one. The persistence of the hyphae, concerned in the formation of zygospores and their subsequent modification, is very peculiar as compared with the evanescent character of the hyphae which distinguishes the family in general. The utility of the modification, together with that of the rhizoid-like outgrowths which hold the spore, is quite apparent in this particular case; for, owing to the peculiar habits of the host, the fungus is developed in situations such as those described, in which it is liable to be flooded and washed away at any moment when the water of the brook rises even an inch or so. The thick elastic hyphae, under such circumstances, hold the mass of spores with great tenacity, and the whole is fastened to the substratum by the indurated rhizoids with such firmness that a knife is required to scrape it off. It is probable that the whole collection of zygospores, having hibernated thus, germinate in the spring, growing out into a coalescent mass of conidiophores as in the ordinary asexual type (fig. 377); but, although I found specimens that, from their appearance, must have been in the brooks for several months, no spores were observed that showed signs of germination.

The growth of the conidiophores is very luxuriant, greatly exceeding the size of the

host, and extends on either side usually so as to invert the wings, turning them upside down (fig. 377). The color of the mass is more livid than is commonly the case in Empusae and shows no variation towards a greenish hue. The conidia are very variable, usually strongly bent, and are readily distinguished by their neck-like basal portion. The secondary conidia of the second type are remarkably regular in shape (figs. 362–365), and of a type which differs widely from that of the primary spores.

A somewhat remarkable degeneration of the conidiophores was observed in, I think, three instances. The specimens in which this occurred were noticeably different in appearance from the usual conidial form, having a milky color and not presenting the usual appearance of luxuriant growth. On examination the white substance in these specimens proved to be composed of hyphae that had for the most part already broken up into short pieces which were seen to produce at one extremity (figs. 366–367) the singular bodies shown in figs. 368–69, of which the mass covering the insect was chiefly made up. These bodies, which are about the size of the conidia, are almost invariably in the form of an irregular kind of cross, the lateral outgrowths appearing at variable distances from the extremities of the body; but always of about the shape represented in the figures referred to. I saw no sign of any germination in them, though I was unable to make proper cultivations, and I cannot explain their occurrence unless it be due to a degeneration of the mass of conidiophores, which subsequently attempt to fulfil their office in this peculiar fashion. The specimens occurred in the usual situations in company with the normal type, and the cause for the degeneration, if it be such, as well as for the peculiar shape of the resulting bodies is not apparent, nor have I ever seen any condition remotely resembling this in other Empusae.

In the formation of zygospores it should be noted that, unlike the preceding species, the conjugating hyphae are rarely, if ever, septate near the point of union, and are very irregular, running into attenuated branches. The production of a spore from each of the gametes (fig. 369) was sometimes noticed as well as the occurrence of double spores (fig. 373*a*) apparently formed side by side. In one instance (fig. 368) conjugation seemed to have occurred between the apices of hyphae and not by the usual *Spirogyra*-like method.

Empusa (Entomophthora) gracilis nov. sp.

Pl. 21, figs. 379–391.

Conidia slender, subfusiform, with a neck-like papillate basal portion and attenuated apex; strongly curved, rarely straight, containing large oil globules. Measurements $7–9 \times 30–45\mu$, average $40 \times 8\mu$. *Conidiophores* digitate, coalescing over host in a white mass. *Cystidia* of rare occurrence, rounded at the apex. *Secondary conidia* like the primary; or nearly spherical, papillate. *Resting spores* unknown. Host attached to substratum by rhizoids.

Host. Diptera: on very minute gnats.

Habitat. Cullowhee, N. C.

Like *E. variabilis*, with which it is commonly associated, this species seems to attack

only the minutest gnats and is thus very difficult to find. A small number of specimens were taken at Cullowhee in July at different times; but I found it in no other locality and it is apparently very rare. The conidia are very slender and readily separated from those of *E. conica* by their fusiform shape, neck-like basal portion and constantly smaller size, the maximum length being slightly over 45μ.

The species has no interest beyond the fact that it affords a second instance of the peculiar "*conica*" type of conidia, and I can give no information concerning the resting spores.

Empusa (Entomophthora) conica Nowakowski.

Pl. 21, figs. 392–410.

Entomophthora conica, Nowakowski *l. c.* **A**; *l. c.* **B**, p. 155, plates VIII and IX, figs. 1–32.

Conidia long, slender, conical, often strongly curved with a rounded papillate base tapering to the usually blunt extremity; 25–80 × 10–14μ. *Conidiophores* digitate, arising as a rule directly from nearly spherical hyphal bodies and coalescing over the body of the host in a clear white mass. *Cystidia* larger than conidiophores, rounded at apex. *Secondary conidia* like the primary or broadly ovoid, rarely pointed at the apex. *Resting spores*, zygospores, produced by a *Spirogyra*-like conjugation, usually budding from one of the gametes; spherical, colorless, 30–50μ in diameter. Host attached to substratum by numerous rhizoids.

Hosts. Diptera: imagines of *Chironomus* and other small gnats.

Habitat. Mt. Washington, N. H., North Carolina, Europe.

The singular shape of the conidia in this and the preceding species distinguishes them at once from all other known Empusae although a transition from the ovoid type to this elongate form is seen in *E. sepulchralis*, *E. variabilis* and *E. rhizospora*. The exact advantage of such a shape it is difficult to understand as the spores do not seem so well calculated to hit and adhere to a passing host as the more blunt forms. In contrast to this elongate form the secondary conidia of the second type are extremely compact, sometimes approaching those of *E. Muscae* in shape. The separation of the conidium proper from the mother cell wall is very commonly seen in this as in other species which vegetate in very moist situations, and the tendency of the spore contents to become more or less contracted is often observable; the contracted portion separating itself from the empty extremity by a cross partition (fig. 396). The conidia themselves vary considerably in size and shape, in the bluntness of their apices which I have never seen as sharply pointed as is represented in Nowakowski's plate, and in the relative thickness of the spore and its amount of curvature. With regard to the curvature of this and other elongate forms, a natural explanation seems to be afforded by the deviation of the conidiophores from a perpendicular position which is usually more or less considerable except in the upper middle portion of the mass. The conidia, while in process of formation, endeavor to correct this deviation by curving upwards thus giving rise to the strongly curved elongate forms as well as to the abruptly bent bases so commonly seen in the *ovispora* type. It is noticeable that this curvature is rarely, if ever seen in Empusae of the *sphaerosperma* type; and the reason for this is very evident in view of the peculiar mode of

growth, already described in the last-named species, which characterizes the mass of conidiophores as a whole, and allows the basidia to assume a vertical position which is impossible in the rounded masses of the usual type.

In material of this species, where the growth of conidiophores has not been luxuriant, the form of the conidia may be constantly such as is represented in figures 403–404; in fact the majority of the specimens obtained from Mt. Washington produced spores of this nature. The affected hosts occurred in this locality on moss along the borders of small brooks in the Alpine Garden, and only when the moss was completely saturated with water, allowing an abundant growth of conidiophores, were the spores of the usual elongate type. I have thought this worthy of mention, since the small form might readily be taken for a distinct species. Although occurring in considerable quantities on Mt. Washington, the species is somewhat rare in North Carolina where it is found in company with *E. variabilis* on saturated wood or stones in the beds of brooks flowing through woods. It may be readily distinguished from the last-named species by the clear white color of the mass of conidiophores.

The resting spores I have found in but few specimens, produced simultaneously with the conidia by a process exactly similar to that described in *E. sepulchralis*.

This completes the enumeration of American *Empusae* at present known, and for convenience of reference I have added below a list of the European species which are unrecorded from this country.

EUROPEAN SPECIES OF EMPUSA AS YET UNRECORDED FROM THE UNITED STATES.

Empusa Jassi, Cohn *l. c.* **B**, p. 77. Sorokin *l. c.* **C**, p. 239. Schroeter *l. c.*, p. 222.

This form, of which no complete description has ever been published, is referred to by Cohn (*l. c.* **B**, pp. 76–77) in connection with his account of *Tarichium megaspermum*. In this place he mentions that the spores are spherical and 20μ in diameter, but gives no specific name to the form, which, he states, occurs on *Jassus 6-notatus*. Where the name *Jassi* first originated I am unable to say, and the species cannot be recognized without further information regarding it. It may prove to be the species previously described as *E. apiculata* which has many hosts, and it forms another element of confusion in the group comprising *E. conglomerata*, *E. Planchoniana*, *E. apiculata*, *E. Jassi* and perhaps *E. Tenthredinis*. I quote below the note of Schroeter in his Silesian flora concerning this species.

"330. *Empusa Jassi*, Cohn, 1870. Mycel im Körper von Cicaden lebend, an den todten Thieren als sammetartiger, weisser Schimmelüberzug hervorbrechend. Conidien kugelig, 20μ Dchm.

Auf *Jassus sex-notatus* Mai, Juni.—Die todten Thiere haften den Grashalmen u. s. w. fest an, die vier Flügel wie zum Fluge ausgespreizt.—Breslau Schmeitig 1869 in grosse Menge."

Entomophthora colorata Sorokin, *l. c.* **C**, p. 215, figs. 573, 623, 627; *l. c.* **D**, p. 62, Pl. III, figs. 5–6, 19–27, Pl. IV, figs. 28, 28′.

This species which is said to occur on grasshoppers seems to be peculiar from its colored conidial spores which, according to Sorokin, are reddish brown, round and resemble those of *E. Muscae* except in color. The protoplasm from the basidium is discharged with the spore. Sorokin states that it closely resembles *E. Grylli*, differing, however, by its round and colored conidia. It is in this species that Sorokin has observed peculiar amoeboid bodies within the host which produce resting spores laterally or terminally. For some further account of this species a review of Sorokin[1] may be found in Just's Bot. Jahresbericht (1881), p. 292, by Batalin.

Entomophthora Tipulae, Fresenius *l. c.*, B p. 206, figs. 46–50. Sorokin *l. c.* C, p. 211, fig. 651.

I find no mention of the occurrence of this species since it was described and figured by Fresenius. The conidia are described as ovoid, with a short, broad, rounded, projecting base; measuring 33-40μ in length. The figures represent a broad almost truncate base and ovoid body which gives the spore a characteristic outline. The species was found on a large *Tipula* which was wingless and adhering to a rush. The mass of spores and hyphae had a greenish brown color. The form should be readily recognized by the large size and peculiar shape of its spores, yet I have seen nothing like it on similar hosts in this country.

Entomophthora Calliphorae, Giard *l. c.*

Entomophthora muscivora (*E. Calliphorae* Giard?), Schroeter *l. c.*, p. 223.

The species described by Giard on large flies (*Calliphora*) can, I think, hardly be distinct from the *E. muscivora* of Schroeter since the rare peculiarity of a deep chestnut-brown (*marron foncé*) resting spore, the measurements of which are the same (30μ in *Calliphorae* and 24–28μ in *muscivora*) is common to both. The hosts and habit correspond in the two forms, *E. muscivora* differing only in the fact that its conidia are also described, while in *E. Calliphorae* they were not observed. Schroeter describes the conidia of his species as ovoid, with a blunt papilla; 20–24μ long by 11–13μ broad. On large flies which are attached by numerous rhizoids. The conidia are slightly smaller than in the form that I have described as *E. Americana* from which it is separated by the peculiarity of the resting spores.

Entomophthora ovispora, Nowakowski *l. c.* A; *l. c.*, B, p. 160, figs. 33–58. Sorokin *l. c.* C, p. 235.

The conidia of this species almost exactly resemble those of *E. echinospora* and *E. Americana*, being somewhat long-ovoid with papillate base and rounded apex. Like *E. Americana* they contain numerous small oil globules of very regular size; but the species is at once separated from either of the forms just mentioned by its peculiar cystidia which are very large, resembling those of *E. sepulchralis* (fig. 306). The conidia measure from 22μ to 28μ in length by 14μ in breadth. The resting spores are zygospores produced by a *Spirogyra*-like conjugation and are of the usual type, 31μ in diameter. The species occurs on flies: *Lonchaea vaginatis, Syrphidae, Sapromyza, etc.*, and is found in wet situations on damp ground, planks, etc.

[1] *l. c.* D.

Entomophthora curvispora, Nowakowski *l. c.* A; *l. c.* B, p. 163, figs. 68–70. Sorokin *l. c.* C, p. 233.

Under this name Nowakowski has described a form peculiar for its strongly curved conidia, which are elongate, rounded at both extremities and measure 10–15μ × 25–40μ. They resemble the curved forms occurring in *E. variabilis*, but are broader and more rounded basally and much larger. The secondary conidia are represented as perfectly spherical. The resting spores are true zygospores produced by a *Spirogyra*-like conjugation; and of the usual form. The species is parasitic upon *Simulia latipes*, a small fly.

Tarichium megaspermum, Cohn *l. c.* B. Sorokin, *l. c.* C, p. 235, figs. 600-602, 598, 599, 635–636. Schroeter *l. c.*, p. 223.

This species is known only from its resting spores, which have been thoroughly described and figured by Cohn, and is parasitic upon the larvae of *Agrotis segetum* which are turned black by the disease. The resting spores are apparently azygospores borne laterally or terminally from hyphae and are peculiar on account of their dark brown epispore which is marked by sinuous furrows. The epispore is also frequently opaque showing no furrows. The spores are spherical and of large size measuring from 34μ to 55μ, average 50μ. The figures given by Sorokin are copied from Cohn's plates and the species has not, I believe, been noticed since its original description. It should be noted that *E. virescens* occurs in America on a similar host and may prove to be identical with this species.

Entomophthora Phryganeae, Sorokin *l. c.* C, 239, figs. 578, 628 *a*, *b*.

Sorokin figures as characteristic of this species a long clavate body with a rhizoid-like basal portion and a terminal round spore with a prominent rather narrow base of attachment. In his text he states that the fungus was found on *Phryganea grandis* (June 26, 1881), growing only on the lower surface (between the first and second pair of legs as indicated in the figure) being wholly superficial and not appearing within the body of the host. The hyphae consist of two portions separated by a septum. The conidia are round 8×6–7μ, the hyphae being 5μ in breadth. The rhizoid-like basal expansion (by which the hypha is apparently attached) is said to be characteristic. It is scarcely necessary to remark that this can hardly be an *Empusa* and its position even among the Entomophthoreae seems very doubtful.

Sorokin remarks concerning this and the succeeding form, that he cannot vouch for their distinctness from lack of material.

Entomophthora pelliculosa, Sorokin *l. c.* C, p. 240, fig. 629.

Under this name Sorokin describes an *Empusa* found on a "flower fly," *Anthomyia pagana*.

"The parasite resembles the ordinary *E. Muscae*, but the discharged conidia have the strange peculiarity of being covered with several layers concentrically distributed, as if a drop of protoplasm discharged simultaneously with the conidia had dried at several different intervals forming each time something in the shape of an envelope. This characteristic is so constant that all the conidia scattered along the substratum were sur-

rounded by sharply defined concentric lines." The figure represents a spore of the *Grylli* type which bears little resemblance to that of *E. Muscae*, so that any determination based upon the figure and description is not possible.

Tarichia uvella, Krassilstchik *l. c.*, p. 95.

Under this name Krassilstchik has described a fungus, growing in coleopterous larvae, which is characterized by the production of a mass of brick-red "*Tarichium*" spores produced by a process not observed, and cohering in small, grape-like clusters as indicated by the specific name. The spores are described as round, papillate, 8–10μ in diameter, surrounded by a wall of no great thickness. In a nutritive fluid they germinated in four days, producing septate hyphae which after a week grew out of the culture fluid and produced single, terminal, cylindrical, colorless spores, $9 \times 3\mu$.

This does not appear to be an *Empusa* from the course of development described, although it might possibly be related to *Massospora*. Concerning this, it is, however, impossible to judge without figures or more detailed information concerning the species.[1]

Massospora Peck.

Massospora cicadina, Peck *l. c.*, p. 44. Leidy, Proc. Acad. Nat. Sci., Phil. Vol. x, p. 235 (no name).

Conidia(?) produced from short hyphae or hyphal bodies, *within* the host; nearly spherical to ovoid, tapering towards a small basal papilla of attachment; smooth or papillate-verrucose, $10 \times 18\mu$–$18 \times 25\mu$, forming a yellowish mass in the abdominal cavity exposed as a coherent mass by the falling away of the abdominal rings. *Resting spores*(?) spherical, roughly reticulated, slightly colored, 38–50μ in diameter (Peck). Host not attached to substratum.

Hosts. Hemiptera: larvae, pupae and imagines of *Cicada septendecem*.

Habitat. New York, New Jersey, Washington, D. C., Illinois, Michigan, Texas.

This singular form should, I think, undoubtedly be placed among the *Entomophthoreae*, although it is decidedly anomalous in some respects. Professor Peck is inclined to place it near *Protomyces* among the Coniomycetes; owing perhaps to the fact that the origin of the spore mass from the characteristic entomophthoroid bodies (figs. 415–419) was not apparent in the types. Whether these spores which fill the whole abdominal cavity are morphologically similar to the conidia of Empusae, or are a kind of azygospore or chlamydospore I am unable to say, having examined only dried material in which it was, of course, impossible to discover the exact process of formation and separation. Their general appearance is certainly that of conidia; yet, unless a columella can be demonstrated in connection with their formation they must be regarded as of a different

[1] *Entomophthora Anisopliae* of Metschnikoff (Zeitschr. d. Kaiserl. Landwirth, Gesell. f. Neurussland, Odessa, 1879, pp. 21–50, with plate), which attacks coleopterous larvae, is perhaps an Isaria, the spores measuring $4.8 \times 1.6\mu$. It is placed by Sorokin (*l. c.* C, p. 268) as belonging to a genus of Basidiomycetes which he calls *Metarhizium*. The names *E. macrospora* (De Bary Vergl. Morphol. d. Pilze) and *E. muscarina* (Comptes Rendus, Vol. 89, p. 750) are apparently printers' errors.

nature. Of these spores there are two kinds usually to be seen in preparations: a larger form nearly resembling an *Empusa* conidium and possessing a perfectly smooth outer wall (figs. 421–423); and a second form, thicker walled, smaller, distinctly papillate in most instances, but produced similarly from hyphal bodies (figs. 424–428). The development of these spores after formation is wholly unknown, although there can be little doubt that they furnish the immediate means of spreading the disease. It should be noted that the anterior portion of the host's body is wholly free from fungus in the specimens which I have examined. The host may thus live for a considerable time after the abdominal rings have begun to fall away and in this manner disseminate the spores by its own movements. That this is the fact seems certain from the observations of Professor French, who writes me that he has seen both larvae and imagos of the locust moving about at Carbondale, Ill., in the condition just described. The probable development of the spores after falling from the host may be inferred from analogy with Empusae generally, and would naturally consist in the production of secondary conidia discharged as in Empusae, and affording the direct means of infection. The smaller type of spore from the considerable thickness of its walls is manifestly adapted to await uninjured the occurrence of conditions favorable to its germination and the hypothetical course of development given above would thus result in a dissemination perhaps quite as effectual as in the usual course adopted by Empusae.

I have included as "resting spores" a second type of spore described by Peck as occurring in certain individuals, although never having seen these spores I am unable to determine whether I am right in so doing. The description quoted gives no note of either their shape or origin, so that I am only justified in considering them resting spores from their analogy to similar spores in *Empusa*.

The distribution of the species is apparently wide, and a further study of the facts connected with its history and development should be full of interest. Whether the fungus is adapted to a subterranean existence, attacking the larvae during their seventeen years of existence and thus appearing subsequently on the fully developed host, or whether it is continued for this long period by resting spores (a supposition highly improbable), or by the infection of isolated specimens of the same or nearly allied hosts which continue the infection during this period, is quite uncertain. It is apparently liable to appear wherever the *Cicada* is known, as shown by the localities above mentioned. I am indebted to the kindness of Mr. L. O. Howard for specimens received from Michigan which, together with an example in Dr. Farlow's herbarium from Texas are the only specimens which I have examined.[1]

Basidiobolus Eidam (1885).

Basidiobolus Ranarum, Eidam *l. c.* Schroeter *l. c.*, p. 224.

Conidia nearly spherical to subovoid, tapering slightly to a rounded base from which the small sharply pointed papilla of attachment projects abruptly. Average measurements

[1] The above was in press before the author had seen the excellent summary of contagious insect diseases by Prof. S. A. Forbes (Psyche, Vol. v, pp. 3–12, Cambridge (1888)), in which he places the present genus among the Entomophthoreae.

37 × 40μ–40 × 45μ. *Conidiophores* arising from single cells of hyphae, simple, much swollen terminally, this swelling developing into a peculiar piece, the basidium, which is discharged with the spore. *Secondary conidia* like the primary, sometimes produced on a capillary conidiophore. *Resting spores*, zygospores, spherical, with an irregularly pitted or folded epispore; 25–45μ in diameter; pale orange yellow or nearly colorless, sometimes opaque from a dark brown incrustation of the epispore; produced by the conjugation of two adjacent cells of a hypha, or of two conidial spores, through the absorption of the intervening cross partition; the union being preceded by the appearance of two finger-like projections, one from either cell, which are applied to one another and, becoming septate near their tips, persist as appendages to the mature spore.

On the excrement of frogs.

Habitat. Cambridge, Mass.; Europe.

Beyond the hitherto unrecorded occurrence, in America, of this most interesting form, I have nothing new to add to the admirable monograph of Eidam above cited. The fungus appeared on the excrement of frogs kept in the biological laboratory at Cambridge for purposes of dissection, and was obtained by filtering the water in which the frogs were kept and placing the sediment in a tin box. I was unable at the time to make artificial cultivations of the spores, by means of which the studies of Eidam were carried out, and the figures given on plate 21 are derived from specimens growing on the natural substratum of the fungus. It is probably for this reason that the production of zygospores seems to vary slightly from that described by Eidam, in that they appear to be formed near the branched extremities of very large and sparingly septate hyphae. The early stages of the process I did not observe, and for a complete morphological history of the species the beautiful plates of Eidam should be consulted.

LIST OF PAPERS CONSULTED.

American.

Arthur, J. C. **A.** On a new larvae *Entomophthora*. Bot. Gazette, Vol. xi, p. 14 (1886), with plate.

B. *Entomophthora Phytonomi* in Bull. N. Y. Agr. Exp. Station, Jan., 1886, with cut.

Bessey, C. E. A new species of insect-destroying fungus. Amer. Naturalist, Vol. xvii, pp. 1280 and 1286 (Dec., 1883).

Peck, C. H. *Massospora cicadina* n. g. et sp. 31st Rep. of State Botanist of N. Y., p. 44 (1879).

In addition to the above one or two catalogue references to *E. Muscae* and *E. Calopteni*.

European.

Bail. Ueber Pilzepizootien der forstverheerenden Raupen. Schriften der naturforschenden Gesellschaft zu Danzig, neue Folge, Band ii, Heft 2, Danzig (1869).

Braun, A. Algarum unicellularum genera nova et minus cognita. Leipsic (1855), p. 105.

Brefeld, O. **A.** Entwickelungsgeschichte der *Empusa Muscae* und *Empusa radicans*. Botanische Zeitung, xxviii, pp. 177 and 161 (1870).

B. Untersuchungen ueber die Entwicklung der *Empusa Muscae* und *E. radicans*. Abhandlung der Naturforschenden Gesellschaft zu Halle, Bd. xii, Heft 1, p. 1 (1871). Plates.

C. Ueber die Entomophthoreen und ihre Verwandten. Botanische Zeitung, xxxv, pp. 345 and 368 (1877).

D. *Entomophthora radicans*. Botanische Untersuchungen ueber Schimmelpilze, Heft iv, p. 97, Leipzig (1881). Plate.

E. *Conidiobolus utriculosus* und *C. minor*. Botanische Untersuchungen ueber Schimmelpilze, Heft vi, p. 35, Leipzig (1884). Plates.

Cohn, F. **A.** *Empusa Muscae* und die Krankheit der Stubenfliegen. Nova Acta Academiae Caesareae Leopoldino- Carolinae Germanicae Naturae curiosorum, XXV, Abh. 1, p. 301, Dresden (1855). Plates.

B. Ueber eine neue Pilzkrankheit der Erdraupen. Beitrage zur Biologie der Pflanzen, Band I, Heft 1, p. 58; (1875). Plates.

Cornu, M. **A.** Note sur une nouvelle espèce d'*Entomophthora*. Bulletin de la Société Botanique de France, XX, p. 189, Paris (1873).

B. Epidémie causée sur des Diptères du genre *Syrphus* par un champignon *Entomophthora* (Cornu et Bronguiart) Association Francaise pour l'Avancement des Sciences, Cougrès de Paris, p. 4; August (1878).

Eidam, E. *Basidiobolus*, eine neue Gattung der Entomophthoraceen. Beitrage zur Biologie der Pflanzen, Band IV, Heft 2, p. 181, Breslau (1886). Plates.

Fresenius, G. **A.** Notiz, Insekten-Pilze betreffend. Botanische Zeitung, Band XIV, p. 882 (1856).

B. Ueber die Pilzgattung *Entomophthora*. Abhandlungen der Senkenbergischen naturforschenden Gesellschaft, Band II, Lieferung 2, p. 201, Frankfurt (1858). Plate.

Fries, E. *Sporendonema Muscae*. Systema mycologicum, Band III, p. 435, Gryphiswaldae (1829).

Giard, A. Deux espèces *d'Entomophthora* nouveaux pour la flore de France. Bulletin Scientifique du département du Nord, Série 2, deuxième annee, No. 11, p. 353, Lisle.

Krassilstschik, I. On diseases of insects caused by vegetable parasites. Mémoires de la Société des Naturalistes de la nouvelle Russie, Vol. XI, part 1, p. 75. Odessa (1886). (*In Russian.*)

Kützing, F. T. *Saprolegnia minor*. Phycologia generalis, p. 157, Leipsic (1843).

Lebert, S. Die Pilzkrankheit der Fliegen. Verhandlungen der Zürcherischeu naturforschenden Gesellschaft, Oct. 29, 1856. Plates.

Lohde, G. Einige neue parastische Pilze. Tageblatt der Naturforschenden Versammlungeu zu Breslau (1874).

Leitgeb, H. *Completoria complens* ein in Farnprothallien schmarotzender Pilz. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. 84, Abth. I, Wien (1882). Plate.

Nowakowski, L. **A.** Die Copulation einiger Entomophthoreeu. Botanische Zeitung, Band XXXV, p. 217 (1877).

B. Entomophthoreae, etc. Proceedings of the Krakow Academy of Sciences (in Polish), 1883, p. 153. Plates.

Phillips, W. *Entomophthora ferruginea*. Annals and Magazine of Natural History, series 5, Vol. XVIII, p. 4 (July, 1886) Plate.

Robin, C. Histoire naturelle des Végétaux parasites qui croissent sur l'Homme et sur les Animaux vivants, avec Atlas de 15 Planches, Paris (1853).

Schroeter, J. Entomophthorei. Kryptogamen-flora von Schlesien, Band III, Lieferuug 2 (Pilze), p. 217, Breslau (1886).

Sorokin, H. **A.** Vorläufige Mittheilung über einige neue *Entomophthora*-Gattungeu. Hedwigia, Vol. XV, p. 146. Dresden (1876).

B. Ueber zwei neue *Entomophthora*-Arten. Beitrage zur Biologie der Pflanzen, Band II, Heft 3, p. 387. Plate.

C. *Entomophthora*. Vegetable parasites of man and animals as a cause of contagious diseases. Vol. II, p. 291, St. Petersburg (1883). Plates. (*In Russian.*)

D. *Entomophthora colorata*, *Aphidis* and *rimosa*. Memoirs of the Imperial Academy of Scieuces, Vol. XXXVII, Book I, p. 58, St. Petersburg (1880). Plate. (*In Russian.*)

Winter, G. Zwei neue *Entomophthoreen*-Formen. Botanisches Centralblatt, Band V, 2, p. 62 (1881). (To this should be added Winter's enumeration of Entomophthoreae in Rabenhorst's Kryptogamen-Flora, Baud I, p. 74, Leipsig (1884), references to which have been inadvertently omitted in the text).

DESCRIPTIONS OF THE PLATES.

*** The following figures are, with the exception of those representing host insects, from camera drawings slightly reduced by photography and done on stone from the negatives. Figures marked with an asterisk were magnified 230 diameters approximately in the original drawings; and the remainder, with the exception of the host insects, were magnified 435 diameters approximately.

PLATE 14.

Empusa Muscae, figs. 1–9.

*Fig. 1. Group of conidiophores showing conidia in several stages of development.
Fig. 2. Basidium after the discharge of the conidium.
Fig. 3. Basidium bearing conidium before discharge.
Fig. 4. Hyphal body germinating within the host.
Figs. 5–6. Conidial spores discharged upon a slide and surrounded by a mass of protoplasm from the basidium.
Figs. 7–8. Secondary conidia of the second type (unlike the primary).
Fig. 9. Secondary conidium of the second type before discharge from the primary conidium.

Empusa Culicis, figs. 10–16.

Fig. 10. Group of conidiophores.
Figs. 11–12. Primary conidia two of which are surrounded by a mass of protoplasm, the two others (*a a*) being free.
Fig. 13. Secondary conidium of the second type before discharge from the primary conidium.
Fig. 14. Secondary conidium of the second type.
Fig. 15. Two chlamydospores formed within the host.
*Fig. 16. A rhizoid formed by the adhesion of two filaments.

Empusa Grylli, figs. 17–48.

*Fig. 17. Group of conidiophores of different ages which have separated themselves from the empty hyphae left behind, by successive cross partitions.
*Fig. 18. Conidium before discharge from the basidium.
*Fig. 19. Upper part of basidium after discharge of the conidium showing the columella as a rounded prominence.
*Fig. 20. Primary conidium producing a secondary conidium of the usual type.
Figs. 21–24. Conidia from grasshopper (Acridian).
Figs. 25–28. Conidia from hairy caterpillar (Arctian).
Figs. 29–30. Conidia from wood cricket (*Ceuthophilus*).
*Figs. 31–35. Successive stages in the formation of resting spores by a possibly sexual process.
*Figs. 36–39. Variations in the process of forming resting spores by the method figured in figs. 31–35.
*Fig. 40. Production of a terminal resting spore asexually from a culture of chlamydospores taken from a caterpillar and made to develop in water upon a slide.
*Fig. 41. A resting spore of irregular shape formed by incomplete budding from a hypha.
*Fig. 42. A resting spore produced within a hyphal body.
*Fig. 43. A resting spore in process of budding from a hyphal body.
*Fig. 44. A mature resting spore.
*Fig. 45. Two septate hyphae taken from the femur of an Acridian, showing a point of anastomosis and numerous small outgrowths together with the lateral production of a resting spore.
*Fig. 46. A chlamydospore germinating.
Fig. 47. A resting spore rendered double by the imperfect union of the two divisions of a hyphal body.
Fig. 48. An Acridian attacked by *E. Grylli*, after remaining a few hours in a moist chamber.

PLATE 15.

Empusa Tenthredinis, figs. 49–55.

Fig. 49. Secondary conidium in process of formation from a primary spore.
Figs. 50–55. Primary conidia from a species of *Tenthredo*.

Empusa conglomerata? figs. 56–62.

Figs. 56–59. Primary conidia from larvæ of *Tipula* sp.
Figs. 60–61. Resting spores in process of formation by budding from hyphal bodies nearly spherical in shape, from the same host.
Fig. 62. Mature resting spore.

Empusa apiculata n. s., figs. 63–75.

*Fig. 63. Conidiophores tending to become digitate. From small fly.
*Fig. 64. Simple conidiophore arising directly from a rounded hyphal body. From small fly.
Fig. 65. A primary conidium germinating and producing a secondary conidium. From small fly.
Figs. 66–68. Primary conidium from small fly.
Fig. 69. Conidium from deltoid moth.
Fig. 70. Conidium from caterpillar of *Hyphantria*.
Figs. 71–73. (*Var. Major*), primary conidia from beetle (*Ptilodactyla serricollis*).
*Fig. 74. Resting spore in process of formation from short hyphae here associated with a cross partition. From Geometrid moth.
*Fig. 75. Terminal portion of a rhizoid from small fly.

Empusa Planchoniana ? figs. 76–81.

Figs. 76–78. Primary conidia from aphides, fig. 77 having a slight apiculus.
Figs. 79–81. Resting spores forming interstitially and terminally from hyphae.

Empusa papillata n. s., figs. 82–90.

*Fig. 82. Conidiophores.
Fig. 83. Secondary conidium in process of development from a primary spore. The columella is forced into the secondary spore probably in this case by the contraction of its contents, the primary spore being empty.
Fig. 84. Terminal portion of a rhizoid.
Figs. 85–89. Primary conidia.
Fig. 90. A mature resting spore.

PLATE 16.

Empusa Caroliniana n. s., figs. 91–105.

*Fig. 91. Conidiophores, one arising directly from a hyphal body.
Fig. 92. A hypha the contents of which have become contracted into hyphal bodies.
Figs. 93–94. Primary conidia from fresh material.
Figs. 95–103. Primary conidia as they appear in dried material.
Fig. 104. Secondary conidium in process of formation from a primary spore.
Fig. 105. A mature resting spore. All these figures are from *Tipula* sp.

Empusa (Triplosporium) Fresenii (figs. 106–140).

*Figs. 106–108. Masses of nearly naked protoplasm from which the hyphal bodies (fig. 127) are formed.
Fig. 109. Conidium before discharge from the basidium.
Fig. 110. Conidium germinating in the ordinary way.
Figs. 111–116. Primary conidia.
Fig. 117. A secondary conidium of the second type produced from a primary conidium, on its capillary conidiophore.
Fig. 118. A secondary conidium of the second type produced from a conidiophore which is neither capillary nor of the usual type.
Fig. 119. A secondary conidium of the second type, borne on a capillary conidiophore, which has begun to germinate before separating from it.
Fig. 120. A secondary conidium of the second type germinating laterally by a capillary conidiophore.
Figs. 121–122. Secondary conidia of the second type germinating from their apices in the usual manner.
Figs. 123–124. Secondary conidia of the second type.
Fig. 124. A primary conidiophore producing three capillary conidiophores, the middle one beginning to swell into a spore.
Fig. 125. A hypha of germination of the usual type, from a primary conidium, has sent up a capillary conidiophore at the tip of which a secondary conidium of the second type is beginning to form.
Fig. 126. A hyphal body germinating to form a conidiophore.
Fig. 127. Two hyphal bodies taken from a mass filling the abdomen of *Aphis*.
Figs. 128–140. Two hyphal bodies lying side by side previous to conjugation begin to show slight prominences on their upper inner sides.
Fig. 129. These prominences have become gametes which have come in contact with one another midway between the two hyphal bodies.
Fig. 130. The partition wall between the gametes has wholly or partially disappeared and a bud has begun to appear rising upwards from their point of union.

Figs. 131–134. Showing this bud in several successive stages of development.
Figs. 135–136. The bud has become the mother cell of a zygospore while the two hyphal bodies remain attached as bladders which contain certain fatty bodies.
Fig. 137. A mature zygospore lying free in its mother cell, the walls having been separated through the absorption of water.
Fig. 138. A small zygospore to which the ragged remnants of the hyphal bodies are still attached as in the previous figure.
Figs. 139–140. Zygospores from which the remnants of the hyphal bodies have wholly disappeared, a remnant of the gametes still adhering to fig. 140.

Empusa (Triplosporium) lageniformis n. s., figs. 141–160.

*Fig. 141. Young conidiophores of a digitate type seldom seen in this species. All the figures are from *Aphides* on white birch (*B. populifolia*).
*Fig. 142. Conidiophores of the usual type.
Fig. 143. A primary conidium of the usual type germinating to produce a secondary conidium of the first type.
Figs. 144–145. Hyphal bodies germinating to form conidiophores.
Figs. 146–154. Primary conidia.
Fig. 155. A primary conidium has produced a capillary conidiophore, the apex of which has begun to swell into a secondary conidium of the second type.
Figs. 156–157. Two primary conidia have produced capillary conidiophores upon which are borne mature secondary conidia of the second type.
Figs. 158–160. Three secondary conidia of the second type in different stages of germination.

PLATE 17.

Empusa (Entomophthora) Lampyridarum n. s., figs. 161–172.

*Fig. 161. Conidiophores of a simple type. The type of the species is however probably compound.
Figs. 162–166. Primary conidia.
Figs. 167–171. Secondary conidia of the second type.
Fig. 168. A secondary conidium of the second type has produced a capillary conidiophore the apex of which is becoming swollen into a tertiary conidium of the same type.
Figs. 169–170. Two primary conidia bearing mature secondary conidia of the second type on capillary conidiophores.
Fig. 172. Appearance of host, *Chauliognathus Pensylvanicus*, attacked by this species.

Empusa (Entomophthora) geometralis n. s., figs. 173–178.

Fig. 173. *Eupithecia* attached to a pine needle by haustoria before death.
Fig. 174. *Thera* similarly attached showing position of conidiophores.
Fig. 175. Group of primary conidia.
Figs. 176–177. Two primary conidia producing secondary conidia of the second type on capillary conidiophores.
Fig. 178. Two secondary conidia of the second type.

Empusa (Entomophthora) occidentalis n. s., figs. 179–199.

*Fig. 179. Rhizoid with irregularly expanded extremity.
*Fig. 180. Digitate conidiophore.
Fig. 181. Basidium and conidium before discharge.
Figs. 182–184. Primary conidia with fat globules.
Figs. 185–189. Primary conidia of the usual appearance. Figs. 183 and 185 are more distinctive of the species.
Fig. 190. Primary conidium which has germinated to produce a secondary conidium of the first type.
Fig. 191. Primary conidium which has produced a capillary conidiophore on which is borne a mature secondary conidium of the second type.
Fig. 192. Primary conidium germinating as in the last figure: the secondary conidium being immature.
Fig. 193. Secondary conidium of the second type.
Fig. 194. Secondary conidium of the second type in process of germination.
Fig. 195. Mature resting spore.
Figs. 196–199. Formation of resting spores by a possible sexual process.

Empusa (Entomophthora) sphaerosperma, figs. 200–219.

Fig. 200. *Colias* attacked by the fungus.
Fig. 201. A small hymenopterous insect similarly attacked.
*Fig. 202. A compound conidiophore.

Fig. 203. Primary conidia from small gnat.
Fig. 204. The same from *Thrips* sp.
Fig. 205. The same from a species of *Musca*.
Fig. 206. The same from an ichneumon.
Fig. 207. The same from *Colias philodice*.
Fig. 208. The same from *Phytonomus* larva.
Fig. 209. The same from rose leaf-hopper (*Typhlocyba*).
Fig. 210. A primary conidium producing a capillary conidiophore on which is borne a mature secondary conidium of the second type.
Fig. 211. The same. The secondary conidium in process of formation.
Fig. 212. A secondary spore of the second type unusually long.
Fig. 213. A secondary conidium of the second type of the usual form.
Figs. 214–216. Resting spores in process of formation from short hyphae, associated with a cross partition in each case.
Fig. 217. Resting spore in process of formation from a single short hypha.
Figs. 218–219. Mature resting spores.

PLATE 18.

Empusa (Entomophthora) Aphidis, figs. 220–240.

*Fig. 220. Compound conidiophore.
*Fig. 221. Cystidium.
Fig. 222. Simple conidiophore: the protoplasm in the basidium has separated itself from the empty hypha below by successive cross partitions.
Figs. 223–236. Primary conidia.
Fig. 237. Two secondary conidia of the second type.
Fig. 238. A primary conidium bearing a secondary conidium of the second type.
*Fig. 239. A hyphal body germinating in all directions.
Fig. 240. A primary spore germinating in water, the protoplasm separating itself by cross partitions from the empty hypha.

Empusa (Entomophthora) dipterigena n. s., figs. 241–250.

Figs. 241–247. Primary conidia from a small fly, figs. 243 and 244 being characteristic of the species.
Fig. 248. Primary conidium bearing a secondary conidium.
*Fig. 249. Rhizoid with terminal expansion. The divisions of the expansion should be more truncate.
Fig. 250. A mature resting spore produced externally.

Empusa (Entomophthora) virescens n. s., figs. 251–261.

Fig. 251. Digitate conidiophore.
Figs. 252–259. Conidia.
Fig. 260. Conidium which has been discharged without the rupture of the mother-cell wall which has merely stretched.
*Fig. 261. Hyphal body germinating in all directions.

Empusa (Entomophthora) Americana n. s., figs. 262–273.

*Fig. 262. A group of rhizoids.
Figs. 263–271. Conidia.
" 272–273. Two mature resting spores; fig. 272 showing separation of the inner and the two outer walls.

Empusa (Entomophthora) montana n. s., figs. 274–285.

*Fig. 274. A digitate conidiophore produced directly from a chlamydospore.
*Fig. 275. Two cystidia.
*Fig. 276. Terminal portion of a rhizoid showing its attachment to a bit of *Sphagnum*.
Fig. 277. Gross appearance of the fungus many times enlarged.
Figs. 278–285. Conidia.

PLATE 19.

Empusa (Entomophthora) echinospora n. s., figs. 286–305.

Figs. 286–294. Conidia.
Fig. 295. Terminal portion of a rhizoid.

Fig. 296. A zygospore which seems to have resulted from a double conjugation.
Fig. 297. A group of sporophores emerging from the host's body previous to the formation of zygospores. One of their number has grown beyond the rest and subsequently forms part of a network which holds the mass of external zygospores.
Figs. 298–299. Two instances of external conjugation.
Fig. 300. Conjugation taking place within the host.
Figs. 301–302. Further examples of external conjugation.
Figs. 303–304. Resting spores formed internally, the process of conjugation not visible.
Fig. 305. Mature resting spore.

Empusa (Entomophthora) sepulchralis n. s., figs. 306–326.

*Fig. 306. A cystidium somewhat immature.
*Fig. 307. The terminal portion of a cystidium at a more advanced stage.
*Fig. 308. A digitate conidiophore arising directly from a spherical hyphal body.
Fig. 309. A hyphal body beginning to germinate.
Figs. 310–317. Primary conidia.
Figs. 318–319. Secondary conidia of the second type.
Fig. 320. Primary conidium in which the mother-cell wall has separated from the spore, remaining attached only at its point of dehiscence from the basidium.
Fig. 321. Primary conidium in which the separation from the mother-cell has become complete.
*Fig. 322. Conjugation of two hyphae and first budding of the zygospore from one of the gametes.
*Figs. 323–325. Several stages in the formation of a zygospore. In fig. 325 the whole contents of the conjugating cells have passed into the zygospore.
Fig. 326. Mature zygospore. (The circles of dots are due to careless engraving).

PLATE 20.

Empusa (Entomophthora) variabilis n. s., figs. 326–345.

*Fig. 327. Compound conidiophore.
*Fig. 328. Rhizoids.
Figs. 329–342. Primary conidia.
Fig. 343. Primary conidia among the first discharged.
Fig. 344. Formation of a secondary conidium of the first type.
Fig. 345. Formation of a secondary conidium of the second type.
Fig. 346. Secondary conidium of second type.

Empusa (Entomophthora) rhizospora n. s., figs. 347–378.

*Fig. 347. Conidiophore arising from spherical hyphal body.
*Fig. 348. Cystidium.
Figs. 349–360. Primary conidia.
Fig. 361. Production of secondary conidium of the first type.
Fig. 362. Production of secondary conidium of the second type.
Figs. 363–365. Secondary conidia of the second type.
Figs. 366–367. Production of "pseudoconidia" from hyphal bodies resulting from the general degeneration of the conidiophores.
Figs. 368–369. Two of the pseudoconidia fully developed.
*Fig. 370. Formation of a zygospore by the conjugation of the free ends of two hyphae.
*Fig. 371. *Spirogyra*-like conjugation resulting in the production of a spore from both gametes.
*Figs. 372–373. Two similar points of conjugation in which the rhizoid-like enveloping processes are developing from the base of the spore.
*Fig. 374. Group of mature zygospores showing indurated hyphae and rhizoid-like processes.
Fig. 375. A single zygospore.
Fig. 376. A zygospore freed from the epispore.
Fig. 377. A "Caddis fly" showing the growth of conidiophores.
Fig. 378. Gross appearance of the zygospores produced externally over the host.

PLATE 21.

Empusa (Entomophthora) gracilis n. s., figs. 379–391.

*Fig. 379. Conidiophore.
Fig. 380. Production of secondary conidium of the first type.

Fig. 381. Secondary conidium of the second type.
Figs. 382–391. Primary conidia.

Empusa (Entomophthora) conica, Nowakowski, figs. 392–408.

*Fig. 392. Conidiophore originating from spherical hyphal body.
Fig. 393. Cystidium.
Figs. 394–402. Primary conidia.
Figs. 403–404. Primary conidia produced in dryer situations.
Fig. 405. Production of secondary conidium of the first type.
Figs. 406–407. Secondary conidia of the second type.
Fig. 408. Production of secondary conidium of the second type.
*Fig. 409. Production of a zygospore by *Spirogyra*-like conjugation.

Basidiobolus Ranarum, Eidam, figs. 140–144.

Fig. 410. Conidiophore with conidium budding from its apex.
Fig. 411. Conidium still connected with the basidium.
Fig. 412. The basidium (*a*) separated from the conidium.
Figs. 413–414. Zygospores in different stages of development with the "nabel" (*a*,*a*), persistent.

Massospora cicadina, Peck, figs. 415–429.

Figs. 415–417. Hyphal bodies.
Figs. 418-420. Production of spores from hyphal bodies.
Figs. 421–423. Spores of the larger and smooth type.
Figs. 424–428. Spores of the usual type.
Fig. 429. One of the same spores seen in optical section,

NOTE.—The present investigation was carried on in the Cryptogamic laboratory of Harvard University and was presented as a graduating thesis May 1, 1888.

CONTENTS.

Summary of Entomogenous plants, . . 134
Facultative parasites of insects, . . 136
Entomophthoreae:
General characters, ... 136
The genus *Completoria*, ... 137
The genus *Conidiobolus*, ... 137
The genus *Basidiobolus*, ... 138
The genus EMPUSA:
Infection and production of hyphal bodies, 139
Germination of the hyphal bodies and chlamydospores, ... 141
Formation of conidiophores, . . 142
Formation and discharge of the conidia, 143
The conidia and their germination, . . 144
Secondary conidia, ... 145
Cystidia and rhizoids, ... 146
Formation of zygospores and azygospores, 146
Hosts of Empusae, ... 150
The habitat of Empusae, ... 151
Miscellaneous notes, ... 151
Subgenera of *Empusa*, ... 152
Systematic enumeration of species:
American species of *Empusa*, . . . 155
European species of *Empusa*, . . . 187
Massospora 190
Basidiobolus 191
List of papers consulted 192

INDEX OF GENERA AND SPECIES.

Appendicularia entomophila, 135.
Aspergillus, 136.

Basidiobolus, 136, 138, 148, 150.
B. ranarum, 191.
Botrytis Bassiana, 136.

Completoria complens, 137.
Conidiobolus, 137, 139, 140, 148, 150.
C. utriculosus, 138.
C. minor, 138.
Cordyceps, 135, 136.
C. armeniaca, 136.

Empusa, 139, 153, 154.
E. Americana, 179, 177, 180, 181.
E. Aphidis, 175, 140, 142, 151, 153, 165, 166, 178.
E. apiculata, 163, 142, 143, 153, 165, 167, 187.
E. aulicae, 159, 162.
E. Calliphorae, (188) 149, 179.
E. Calopteni, 159.
E. Caroliniana, 167, 155.
E. colorata, (187) 140, 168.
E. conglomerata, 162, 142, 159, 161, 164, 166, 187.
E. conica, 186, 141, 147, 151, 153, 182, 183.
E. Culicis, 157, 143, 153, 165.
E. curvispora, (189) 140, 147, 153, 182.
E. dipterigena, 177, 175, 180, 181.
E. echinospora, 180, 146, 148, 149, 177, 179.
E. Freseniana, 168.
E. Fresenii, 167, 140, 145, 148, 149, 151, 152, 153, 169, 176.
E. geometralis, 170, 151.
E. gracilis, 185, 144, 151.
E. Grylli, 159, 140, 143, 149, 150, 152, 153, 162, 163, 165, 166, 173, 188.
E. Jassi, 187, 164.
E. lageniformis, 169, 151, 152, 171.
E. Lampyridarum, 169, 155.
E. macrospora, 190.
E. major, 164.
E. megasperma, (189) 149, 178.
E. montana, 180.
E. Muscae, 155, 141, 142, 144, 151, 153, 186, 188, 189.
E. muscarina, 190.
E. muscivora, (188), 149, 179.
E. occidentalis, 171, 147, 161, 169, 175.
E. ovispora, (188), 140, 147, 177, 179, 182.
E. papillata, 166, 151, 153.
E. Planchoniana, 165, 164, 187.
E. radicans, 172, 145, 150.
E. rimosa, 177.
E. rhizospora, 183, 149, 182, 186.
E. sepulchralis, 181, 141, 179, 186, 187.
E. sphaerosperma, 172, 140, 145, 147, 150, 151, 152, 158, 164, 171.
E. Tenthredinis, 162, 187.
E. Tipulae, (188).
E. variabilis, 183, 151, 186, 187, 189.
E. virescens, 178, 142, 189.
Enterobryus, 135.
Entomophthora, 153.
E. Americana, 179.
E. Anisopliae, 190.
E. Aphidis, 175.
E. aulicae, 159.
E. Calliphorae, 188.
E. Calopteni, 159.
E. colorata, 187.
E. conglomerata, 162.
E. conica, 153, 186.
E. Culicis, 157.
E. curvispora, 153.
E. dipterigena, 177.
E. echinospora, 180.
E. geometralis, 170.
E. gracilis, 185.
E. Grylli, 159.
E. Jassi, 187.
E. Lampyridarum, 169.
E. montana, 180.
E. Muscae, 155.
E. muscivora, 188.
E. occidentalis, 171.
E. ovispora, 153, 188.
E. Planchoniana, 165.
E. pelliculosa, 189.
E. Phryganeae, 189.
E. radicans, 153, 172.
E. rimosa, 177.
E. sepulchralis, 181.
E. sphaerosperma, 172.
E. Tenthredinis, 162.
E. Tipulae, 188.
E. variabilis, 183.
E. virescens, 178.

Isaria, 136, 190.

Laboulbenia, 135.
Lamia, 153.
L. Culicis, 157, 153.

Massospora, 137, 139, 190.
M. cicadina, 190.
Metarhigium, 190.
Myiophyton, 154.
M. Cohnii, 155.

Penicillium, 136.
Piptocephalis, 149.
Protomyces, 190.

Saccharomyces, 154.
Saprolegnia minor, 157.
Sporendonema, 154.
S. Muscae, 155.

Tarichium, 139, 149.
T. Aphidis, 175.
T. megaspermum, 189, 187.
T. sphaerospermum, 172.
T. uvella, 190.
Triplosporium, 152.
T. Fresenii, 167.
T. lageniformis, 169.

INDEX OF HOST-INSECTS.

Acridians, 159.
Agrotis fennica, 178.
A. segetum, 189.
Anthomyia, 156.
A. pagana, 189.
Aphides, 165, 168, 169, 171.
Aphis, 172.
A. mali, 168.
Arctians, 159.
Bug, 177.
Calliphora vomitoria, 155, 188.
Caloptenus, 160.
Ceuthophilus, 159, 162.
Chauliognathus Pensylvanicus, 170.
Chirouomus, 180, 186.
Cicada septendecem, 190.
Coleoptera, 170, 172, 190.
Colias philodice, 172, 174.
Coriseae, 177.
Culex, 158, 163.
Culicidae, 172.
Deltoid moth, 164.
Diptera, 155, 158, 159, 163, 164, 166, 167, 172, 180, 181.
Eupithecia, 171.
Flies, 155, 158, 164, 179, 188.
Gnats, 158, 164, 166, 185, 186.
Grasshoppers, 159, 188.
Halictus, 172.
Hemiptera, 164, 165, 168, 169, 171, 175.
Hyphantria textor, 159, 160, 164, 165.
Hymenoptera, 162, 172.
Ichneumonidae, 172.
Jassus 6-notatus, 187.
Lampyridae, 170, 172.
Lepidoptera, 159, 164, 171, 172, 178.
Limnophilus, 172.
Lonchaea vaginalis, 188.
Lucilia Caesar, 155, 179.
Musca, 155, 172.
M. domestica, 155, 172.
M. vomitoria, 179.
Mycetophelidae, 172, 177.
Neuroptera, 172.
Orgyia nova, 159, 161.
Orthoptera, 159.
Petrophora, 164, 171.
Phryganea grandis, 189.
Phryganeidae, 184.
Phytonomus punctatus, 172, 173.
Pieris, 172, 174.
Ptilodactyla serricollis, 164.
Pyrrharctia isabella, 160.
Sapromyza, 188.
S. longipennis, 180.
Simulium molestum, 158.
S. latipes, 189.
Spilosoma virginica, 159.
Syrphidae, 155, 188.
Syrphus, 156.
Tenthredo, 162.
Thera, 171.
Thripidae, 172.
Thrips, 172, 174.
Tipulidae, 159, 172, 181.
Tipula, 161, 163, 167, 177, 188.
Tortrix, 164.
Typhlocyba (mali et rosae), 164, 172, 173.

ERRATA.

Page 142, line 11 and p. 143, line 6; for *apiculatus* read *apiculata.*
Page 153, line 11, after *conica* insert *radicans.*
Page 141, 3d line from bottom, for condition read — conditions.
Page 150, lines 6 and 9 and p. 174, line 26, for Krasilstchik read — Krassilstchik.
Page 166, line 10, after separation insert — is.
Page 190, line 4, for *Tarichia* read — *Tarichium.*
Page 192, line 27, for larvae read — larval.
Page 200, for Metarhigium read — Metarhizium.
Plate xv, for var. apiculata read — apiculata.

VII. The Flora of the Kurile Islands.

By K. Miyabe.

Introduction.

General Remarks.

So far as I am aware, no special work devoted to the flora of the Kurile Islands has ever been published. The glimpses we could get of its character have chiefly been from the scattered writings of Russian botanists. In his "Flora Rossica," Ledebour attributes about forty species to these islands. Before his time, Pallas,[1] Georgi,[2] Turczaninow,[3] Chamisso and Schlechtendal,[4] De Candolle[5] and Ruprecht,[6] referred occasionally in their writings to the Kurile plants. Most of these plants, however, were included by Ledebour in his "Flora."

Since the appearance of that important work, many additions have been made to our knowledge of the Kurile vegetation by Regel,[7] Maximowicz,[8] Herder,[9] Fr. Schmidt,[10] Siebold,[11] Boott,[12] and others.[13] The total number of plants of these islands known to me from the writings of these authors is 104 species.

The materials on which most of these references were based had been collected by the Russian naturalists and naval officers in the northern Kuriles, as far south as Urup, and are now incorporated chiefly in the herbaria of St. Petersburg. Prof. Maximowicz, who has noted every Kurile plant he has come across in these herbaria since 1868, most generously placed his valuable list in my hands

[1] Pallas, P. S.; Neue Nordische Beiträge, Vol. IV, pp. 112–141. St. Petersburg & Leipzig, 1783. —— Flora Rossica, Tom. I, pars 1, 2. Petropoli, 1784–1788. —— Species Astragalorum. Lipsiæ, 1800.

[2] Georgi, J. T.; Geographisch-physikalische und naturh. Beschreibung des Russ. Reiches. 3ten Theils 4ter Band, pp. 609–1072. Konigsberg, 1800. —— Nachträge fur dessen Geog., etc., 1802.

[3] Turczaninow, N.; Description de deux nouveaux genres de la familie des Gentianées. —— Observations sur quelques genres et espéces de la familie de Borraginées. ——Decades quatuor plantarum hucusque non descriptarum, Sibiriae maxime orientalis, etc. (Bulletin de la Soc. des Natur. de Mosc., 1840.)

[4] Chamisso, Ad de, and Schlechtendal, D. d.; De plantis in expeditione speculatoria Romanzoffiana observatis. (In Linnæa, III (1828), p. 38, VI (1831), p. 574, on the plants in Herb. Willd.)

[5] In the "Systema" and "Prodromus," based mostly on the specimens in Herb. Fisch.

[6] Ruprecht, F. J.; Distributio Cryptogamarum Vascularium in Imperio Rossico (Beiträge zur Pflanzenkunde des Russ. Reiches. Dritte Lief. St. Petersburg, 1845).

[7] Regel, E.; Uebersicht der Arten der Gattung Thalictrum, welche im russischen Reiche und der Angränzenden Ländern wachsen. Moskau, 1861.——Regel & Tiling, H.; Florula Ajanensis. Mosquae, 1859. —— Regel; Plantae Raddeanae, Vol. I, 1861–2.

[8] Maximowicz, C. J.; Primitiae Florae Amurensis. St. Petersb., 1859. —— Diagnoses plantarum novarum Japoncae et Mandshuriae (Mélanges biologiques tirés du Bull. de l'Acad. imp. des Sciences de St. Pétersbourg, Tom. VIII, IX, 1872–1876). —— Diagnoses plantarum novarum Asiaticarum (Mél. biol., IX–XII, 1876–1888). —— Rhododendreae Asiae Orientalis (Mém. de l'Acad. imp. St. Pétersb., 7e sér., t. XVI, n. 9) 1870. —— Adnotationes de Spiræaceis (Acta H. Petrop. Tom. VI) 1879.

[9] Herder, F. von; Plantae Raddeanae, Vol. III, IV, 1864–1887.

[10] Schmidt, Fr.; Flora Sachalinensis, in Reisen im Amurlande und auf der Insel Sachalin (Mém. Acad. imp. St. Pétersb., 7e Sér., t. XII, n. 2) 1868.

[11] Siebold et Zuccarini; Flora Japonica. Lugd. Bot. 1835–1870.

[12] Boott, F.; Illustrations of the Genus Carex. 4 vols. 1858–1867.

[13] Many references to the Kurile plants are found in some of the recent monographs, as Haussknecht on Epilobium, Elwes on Lilium, Bunge on Oxytropis, Masters on Japanese Conifers, etc. In Turczaninow's Flora Baicalensis-Dahurica, about half a dozen references occur.

with full consent that it should be published with my own. The list contains one hundred and nine species, of which thirty-eight have not yet been recorded as growing in these islands, in any publications with which I am acquainted.

The first naturalists who visited the Kurile Islands were G. W. Steller and S. P. Krascheninnikof. They crossed over from Kamtschatka about 1740, either together or separately, and collected in the islands of Shumshu and Paramushir.[1] Of their botanical collections, the larger part was worked over and published by Pallas. Some of their sea-weed collections are mentioned in S. T. Gmelin's Historia Fucorum.[2]

In 1788, Merk, a doctor in Irkutsk, who accompanied, as naturalist, the expedition to the Northern Pacific under Comm. Billings, made collections in some of the northern Kuriles. Of his collections, a part is still preserved in the Fischer Herbarium, and also in the Willdenow Herbarium. They were made known chiefly by the labors of Pallas and Rudolph. The results of the study of the latter were published in the writings of Georgi.[3]

Langsdorff under Krusenstern (1803–1806), and Chamisso under Kotzebue (1815–1818) seem also to have made brief visits to some of the northern Kuriles during their cruise in the N. Pacific.[4]

Most of the later collectors were officers of the Russian surveying ships. In 1833, Baron Wrangell visited Urup and made some collections of its plants. These specimens are now in the Herbarium of the Academy in St. Petersburg. The only collector who made a prolonged tour among these islands, collecting plants on Shumshu, Paramushir and Urup, was Vosnesenski, the late curator of the Zoological Museum of the Academy, in 1844.[5]

Orloff, a Russian naval officer, who is better known as a collector in the northeastern part of Manchuria, 1849–1850, collected also in the Kuriles.[6]

It must be borne in mind that, on account of strong currents, dense fogs and want of harbors (especially in the northern Kuriles), navigation among these islands is rendered very dangerous, and landing on their shores almost impossible, unless favored with unusually calm weather. Therefore the visits of these collectors were generally limited to a few hours, or, at most, to a day, at one place. Under such unfavorable physical conditions, it is not surprising that in spite of the zeal of many of the collectors who have visited these uninviting shores, we have after all comparatively little knowledge of the vegetation of these islands.

In the summer of 1884, while I was travelling on the northeastern coast of Yezo, an unexpected opportunity for visiting some of the southern Kuriles was offered me. When I reached the harbor of Nemuro on the 27th of July, I found a small steamer on the point of starting for Shikotan, Etorofu, and Urup. With scarcely any time for necessary preparation, I went on board the *Kyorin-maru* accompanied by Mr. N. Kindaichi, the head-gardener of the Botanic Garden of Sapporo Agricultural College, who greatly assisted me in collecting plants during the whole trip. About noon of the next day we were at the Shakotan harbor on the northern coast of the island of Shikotan. In this place we collected most assidnously for two hours and a half. The next day, a little before noon, we reached a small fishing cove on the northern coast of Etorofu, called Furubetsu. From that place we started at once on foot for Shana, another fishing station situated on the same side of the coast about twenty miles distant, and the best harbor of the whole island. The country which we passed through during

[1]Krascheninnikof, S. P.; The History of Kamtschatka and the Kurilski Islands (original in Russian, 1754–1755). English transl. by James Grieve, p. 37. Gloucester, 1764. —— Pallas; Flora Rossica, p. III (Introduction).

[2]Bongard, M. H. G.; Historical Sketch of the Progress of Botany in Russia. (Hooker's Companion to the Botanical Magazine, Vol. I, p. 177; 1835).

[3]Sauer, M.; An Account of a Geographical and Astronomical Expedition to the Northern parts of Russia, etc., under Comm. J. Billings, in 1785–1794. London, 1802. ——Linnæa, VI, p. 574.——Georgi, Beschr. Russ. Reiches, III, 4, p. 619.

[4]Regel, Pl. Radd. p 242. —— Prof. Maximowicz informs me that Chamisso visited these islands.

[5]These facts I owe to Prof. Maximowicz.

[6]Herder, F. von; Biographische Notizen über einige in den Plantæ Raddeanæ genannte Sammler und Autoren. (Engler, Bot. Jahrbücher, IX (1887) p. 443. —— Plantæ Radd. IV, 1, p. 232.

this short inland trip is of the most diversified character, ranging from sheltered valleys thickly covered with deciduous trees and bamboos to exposed mountain-tops entirely clothed with the straggling *Pinus pumila*, and from sandy and rocky beaches to sphagnous bogs on marine terraces. Thus I was able to observe and collect more than two hundred species of the phanerogams and vascular cryptogams of this island, which, I believe, would fairly represent the general flora of the southern Kuriles.

On the 31st, the steamer took us from Shana to Shibetoro, a fishing station near the northern extremity of the same island. There we had only an hour and a half at our disposal to spend on its hillsides. So far the weather had been uncommonly fine and calm. But the regular Kurile weather soon set in, preventing our landing on the island of Urup.

The number of species that I collected and observed[1] in the island of Etorofu is 202; and in Shikotan, 86. All my Kurile specimens are now preserved in the Herbarium of Sapporo Agricultural College, Japan. What duplicates I had of them I have distributed, together with those of my Yezo collections, to the herbaria of the Imperial University of Tokyo, of the Botanic Garden of St. Petersburg, and of Harvard University.

The first list of my Kurile collections was made soon after my return to Sapporo from that trip in 1884. It was sent to my friend, Prof. J. Matsumura of the Imperial University of Tokyo, who read it for me before the November meeting of the Botanical Society of the same year. By the courtesy of Professor R. Yatabe, I was allowed to spend about five months, in 1885, in his laboratory in the University of Tokyo, working up my Kurile and Yezo collections. Some important corrections were there made in my former list.

But it was not until I came to Harvard University that the idea of publishing this list in the present shape was formed. I am indebted to the late Dr. Asa Gray for first suggesting the publication of such a list, which, in his opinion, would be equally interesting to American and to Japanese botanists.

This work I was able to begin in earnest during the summer of 1888 in the Gray Herbarium, where, by the kindness of Dr. Sereno Watson, I was allowed the use of its extensive collections and library. For this particular work there could be few places better suited than this Herbarium, which is especially rich in specimens from the western and northwestern portions of North America, and the islands in the Behring Sea. The vegetation of eastern and northeastern Asia is also very largely represented by the valuable collections of Charles Wright, Williams and Morrow, J. Small, Maximowicz, Albrecht, Schmidt, Oldham, Tschonoski, Wilfold, Augustinowicz, Maries, Stewart and others.

Under each species I have given the range of its geographical distribution, special attention being paid to its limits in the adjoining countries. For this purpose I have availed myself largely of the labors of Ledebour, Maximowicz, Regel, Herder, Hooker, Gray, Watson, Forbes, Hemsley, Franchet, and many others. As to its range in the rest of Japan, my report is based mainly on the collections in the Imperial University of Tokyo, and also on my own, which especially relates to the island of Yezo.

The citation of the literature under the species is not designed to be complete. As a general rule, I have always referred to some of the principal Floras of the neighboring countries, and also to one or more works of a general character, in which can be found a description of the species. A work in which any reference to the Kurile plant as such is made is usually cited under that species. In the case of a critical species, fuller references to its literature and synonymy are given.

During the preparation of this paper, I have been greatly indebted to Dr. Sereno Watson, whose judgment I have freely sought, and on whose suggestions I have acted, on many points of doubtful and critical character. I owe much also to Prof. G. L. Goodale, who has kindly suggested many valuable changes. To Prof. C. J. Maximowicz I am under very great obligations. To his generosity

[1] Want of space in my press-papers obliged me toward the end of the trip to resort to simply noting down on the spot the occurrence of plants of whose names I was absolutely certain.

and kindness this paper largely owes any claim it may have to completeness. Prof. W. Trelease kindly supplied me with information relating to the species of Epilobium; and Mr. James Bisset, F. L. S., in regard to a certain plant collected by Prof. J. Milne on the northern Kuriles.

Physical Geography of the Islands.

The Kurile Islands, or *Chishima* (Thousand Isles), as they are called in Japan, comprise about twenty-four principal islands, with several smaller ones scattered around them, extending in a regular chain, about 795 miles long, from the southern point of Kamtschatka to the island of Yezo. They form the boundary between the Sea of Okhotsk and the Northern Pacific, which attains just south of this group the enormous depth of 27,930 feet.

Until 1875, the islands lying north of Vries or Etorofu Strait belonged to Russia; but by the treaty of that year the whole of the Kurile Islands were placed under the rule of the Japanese Empire. The name Hokkaido — the North Sea district — is now applied to the Kuriles, Yezo, and its adjacent smaller islands collectively.

Beginning at the north, the islands which are habitable[1] are Shumshu, Paramushir, Shiashkotan, Matua, Rashua, Urup, Etorofu or Iturup, Kunashiri and Shikotan. The rest of the islands, chiefly on account of their barrenness and lack of good drinking water, have been left uninhabited. They are visited for game by the inhabitants of the neighboring islands only in times of perfect calm during summer.

Speaking in a general way, the islands are precipitous and unapproachable on the southern side. The few coves and bays which they possess are situated on the northwestern or northeastern sides. These do not serve, however, as safe places of shelter for ships when the wind is unfavorable.

The whole chain of islands is washed by the strong cold currents which come down from the northern part of the Sea of Okhotsk, and also from the Behring Sea. Between the islands there are strong currents, varying in strength from time to time according to the force of the tidal swell from the Pacific. These cold currents, after quitting the Kurile Islands, descend along the eastern and southern coast of Yezo, forming a stream known in Japan as the *Oyashiwo*. At times it comes even as far south as Kinkwazan and Inuboye in the main island of Japan.

Quite close to the east of this cold current, a branch of the Kuroshiwo or Black Stream runs northeastward to the Behring Sea. According to Blakiston (Japan in Yezo, p. 22), these two opposing currents approach within fifteen miles of each other at Cape Erimo, Yezo, with the difference of temperature of 15° F. Whenever the easterly or southerly wind blows over the region, the whole chain of islands is enveloped in the densest fog. This continues usually for a long time, and is said to surpass even that of the far-famed coasts of Newfoundland.

There is another branch of the Kuroshiwo, which enters the Sea of Okhotsk through the Strait of La Pérouse, after washing the whole western coast of Japan. Its trace is lost as it approaches the northern coasts of Kunashiri and Etorofu. The effect of this warm current on the climate and vegetation of these two southern islands can hardly be overestimated.

From November till April or May, all the islands are locked up in ice. Even in the month of June navigation in these seas is sometimes made dangerous by the sudden appearance of drifting ice from the north. As to the temperature of these islands, we have no observations for any length of time, or that are of any value. That there exist great differences in the temperature between the northern and southern islands is evident even from the difference in their latitude (about 8°), and from the influence of the different ocean currents. According to the records of the navigators who

[1] Pallas; Neue Beschreibung der Kurilischen Inseln. (Neue Nordische Beiträge, IV, p. 112–141, 1783.)

have cruised among them, all the islands lying north of Urup are perpetually capped with snow. Their vegetation also indicates decidedly their sub-arctic character.

According to Prof. J. Milne,[1] who has visited the Kurile islands twice since 1878, the whole chain is of volcanic origin. By him and by Captain Snow, fifty-two well-defined volcanic cones were recognized, of which seventeen were active. All these active volcanoes, with the exception of one or two, are confined to the northern Kuriles, where even those which are apparently extinct still preserve their symmetrical slopes, indicating that they have suffered but little from denudation since they were first built up. Professor Milne failed to discover any trace of stratified rocks in the northern group. From these observations he concludes that the formation of the northern Kuriles must be comparatively recent; and, in fact, some of them are now actively forming.

On the other hand, the volcanoes of Kunashiri and Etorofu are mostly rounded in shape and deeply cut by valleys. The neighboring island of Urup presents appearances similar to these two. Along the coasts of these islands, Professor Milne noticed the existence of stratified rocks and terrace formation. These facts show that they are older than the other members of the Kurile group, and formed "the first of a series of stepping stones, which connects Japan, by means of Kamtschatka, with the remainder of Asia." Accepting Croll's theory as true, the presence of marine terraces in the southern Kuriles forms good evidence of their existence before the Glacial Epoch.

Character of the Kurile Flora and its Relations to the Flora of the Neighboring Countries.

According to our present knowledge, the number of orders, genera and species in the Kurile flora, under each of the greater divisions of the vegetable kingdom, is as follows:—

	Orders.	Genera.	Species.
Polypetalæ.	21	69	121
Gamopetalæ.	14	58	100
Monochlamydeæ.	6	12	19
Dicotyledons.	41	139	240
Monocotyledons.	7	33	53
Angiospermæ.	48	172	293
Gymnospermæ.	1	5	6
Phanerogamæ.	49	177	299
Cryptogamæ (Vascul.)	4	10	18
Total.	53	187	317

Among the orders, those which are comparatively rich in genera and species stand in the following sequence:—

Compositæ,	with 15 genera.	Compositæ,	with 30 species.
Rosaceæ,	" 12 "	Rosaceæ,	" 23 "
Liliaceæ,	" 12 "	Gramineæ,	" 17 "
Gramineæ,	" 11 "	Ericaceæ,	" 16 "
Ranunculaceæ,	" 8 "	Caryophyllaceæ,	" 15 "
Ericaceæ,	" 8 "	Liliaceæ,	" 15 "
Cruciferæ,	" 7 "	Scrophulariaceæ,	" 14 "
Umbelliferæ,	" 7 "	Ranunculaceæ,	" 13 "

[1] Milne, J.; A cruise among the volcanoes of the Kurile Islands (Geological Magazine, 1879, p. 337). —— The Kurile Islands (Geol. Mag., 1880, p. 91). —— Evidences of the Glacial Period in Japan (Trans. Asiatic Soc. of Japan, 1881, p. 53). —— Notes on the Kurile Islands, which appeared in the Japan Gazette in the spring of 1885 (not seen; extracts from it in Nature, 1885, pp. 135 and 209).

Leguminosæ,	with	6	genera.	Cruciferæ,	with	12	species.
Saxifragaceæ,	"	6	"	Leguminosæ,	"	9	"
Scrophulariaceæ,	"	6	"	Saxifragaceæ,	"	9	"
Filices,	"	6	"	Cyperaceæ,	"	8	"
Caryophyllaceæ,	"	5	"	Umbelliferæ,	"	7	"
Caprifoliaceæ,	"	5	"	Caprifoliaceæ,	"	7	"
Coniferæ,	"	5	"	Borraginaceæ,	"	7	"
Primulaceæ,	"	4	"	Filices,	"	7	"
Gentianaceæ,	"	4	"	Onagraceæ,	"	6	"
Labiatæ,	"	4	"	Gentianaceæ,	"	6	"
Orchidaceæ,	"	4	"	Polygonaceæ,	"	6	"
				Coniferæ,	"	6	"
				Orchidaceæ,	"	6	"

There are 21 orders which are represented by a single genus; and 9, by a single species.

Among the larger genera, the following are conspicuous: *Carex* (with 8 species); *Stellaria* (with 7); *Artemisia* (6); *Epilobium*, *Senecio*, *Vaccinium*, *Mertensia*, *Veronica* and *Pedicularis* (5 each); *Arabis*, *Viola*, *Prunus*, *Potentilla*, *Saxifraga*, *Achillea*, *Pyrola*, *Polygonum*, *Poa*, *Lycopodium* and *Equisetum* (4 each).

The relative size of these principal orders and genera indicates distinctly the northern nature of the flora. To bring out more clearly a certain peculiarity of the Kurile vegetation, a comparative table, placed below, has been constructed, giving in the first column the names of orders; in the second, the relative percentage which they bear to the whole Kurile flora; and in the third, to that of the flora of Yezo; in the fourth, to that of Saghalin; in the fifth, to that of Amur-land; and in the last column to that of eastern Siberia. The figures in the third column are based on my unpublished list of the Yezo plants, containing a little over 1,100 species. The fourth column I have based entirely on the Flora Sachalinensis of F. Schmidt. The last two columns were taken from Maximowicz's Primitiæ Floræ Amurensis, p. 430.

	Kurile Islands.	Yezo.	Saghalin.	Amur-land.	E. Siberia.
Compositæ.	9.5	7.2	9.1	11.7	9.8
Rosaceæ.	7.3	5.3	5.1	4.9	5.8
Gramineæ.	5.4	4.8	6.8	6·3	4.9
Ericaceæ.	5.0	3.8	4.0		
Liliaceæ.	4.7	4.9	4.0	4.5	3.5 (?)
Caryophyllaceæ.	4.7	2.1	2.2	3.2	5.1
Scrophulariaceæ.	4.4	2.5	2.2	2.4	2.3
Ranunculaceæ.	4.1	3.6	5.0	7.2	8.2
Cruciferæ.	3.7	2.1	3.2	3.5	6.4
Leguminosæ.	2.8	2.3	1.0	3.0	5.3
Saxifragaceæ.	2.8	2.3	2.2		
Cyperaceæ.	2.5	5.1	7.3	4.9	5.6
Umbelliferæ.	2.2	2.6	3.4	2.9	1.7
Caprifoliaceæ.	2.2	1.5	1.8	1.2	1.1
Borraginaceæ.	2.2	.8	.3	1.1	1.1
Filices.	2.2	3.8	3 2	2.3	
Polygonaceæ.	1.8	2.7	2.7	2.8	
Orchidaceæ.	1.8	3.0	3.5	1.5	1.3
Onagraceæ.	1.8	1.0	.8	1.1	0.5

	Kurile Islands.	Yezo.	Saghalin.	Amur-land.	E. Siberia.
Gentianaceæ.	1.8	1.0	.7	1.2	1.9
Coniferæ.	1.8	1.5	1.4		
Labiatæ.	1.2	3.2	1.7	2.9	

From this table it is clear that in Rosaceæ, Ericaceæ, Caryophyllaceæ, Scrophulariaceæ, Caprifoliaceæ and Borraginaceæ the Kurile flora is relatively rich; while in Cyperaceæ (?), Labiatæ and Polygonaceæ it is comparatively poor.

Every order which is represented in the Kurile Islands is also represented in a greater or less degree throughout the northern hemisphere, many passing into the southern.

As to the genera, one hundred and fifty-six or about eighty-four per cent of the total number are amphigæan, that is they are found throughout Europe, Northern Asia and North America. Of the remaining 31 genera, only three, *Skimmia*, *Crawfurdia* and *Acanthopanax*, are restricted to eastern and tropical Asia. Twelve genera may be called Europo-Asiatic, of which *Hemerocallis*, *Adenophora*, *Pleurospermum*, *Ægopodium*, *Filipendula* and *Sorbaria* are so in a strict sense; while *Sonchus* and *Asperula* are found also in Africa and Australia; and *Dianthus*, *Swertia*, *Alopecurus* and *Galeopsis?* extend to northwestern America. The remaining sixteen genera are more or less confined to Asia and North America. We have only four genera in the Kurile Islands which are peculiar to eastern North America and to eastern Asia. They are *Leucothoe*, *Diervilla*, *Hydrangea* and *Astilbe*. The American genera, *Trillium*, *Disporum* and *Clintonia*, are found also in the temperate and mountain regions of Asia; *Aralia*, in eastern and tropical Asia; *Dodecatheon* and *Claytonia*, in northeastern Asia; and *Mimulus*, in extratropical Asia, Africa and Australia. *Tetrapoma* of northeastern Asia is said to occur also in northwestern America. *Boschniakia*, which is peculiar to the north Pacific borders, recurs in North America in Mexico, and in Asia in Himalaya.

As to the species, ninety-seven or about thirty per cent of the Kurile vegetation are distributed throughout Europe, northern Asia and North America. For the northerly situation of the islands, the proportion of the circumpolar species is comparatively small. We shall leave them entirely out of our consideration while we are discussing in the following pages the character and relative proportions of the different elements which constitute the remaining important part of the Kurile flora.

There are only two endemic species, and these of a rather doubtful character: *Draba hirsuta*, Turcz., and *Oxytropis Pumilio*, Ledeb. Both of them were founded on a few imperfect specimens and will most likely prove to be forms of some of the nearly related species, in which these regions are particularly rich. *Prunus Ceraseidos*, Max., var. *kurilensis*, may prove to be a good species. Its relation to the typical form I have dwelt upon at length in its proper place.

Seventeen species and two varieties are restricted to the insular limits of Japan and Saghalin; of these, two species and one variety are peculiar to Hokkaido.

The largest and most important element is the *Northeastern Asiatic*, whose centre of distribution is to be found somewhere around the Sea of Okhotsk. It numbers 31 species and 6 varieties. The next largest is what I have designated, for convenience, the *Eastern Asiatic*, which includes plants of Japan, Saghalin, Manchuria, Corea and China, but not of Kamtschatka and eastern Siberia. This eastern Asiatic element includes 28 species and 3 varieties. Altogether, the species and varieties which are strictly Asiatic in their range of distribution, number 105 and 12 respectively.

Of the species which extend into Europe, there are 55; and into North America, 80. Of these 80 species, 34 are limited to northwestern America, which includes Alaska and British Columbia; while 22 extend further southward on the Rocky Mountains and other high ranges in the Pacific States. The remaining 24 species are all widely distributed across that continent, chiefly in its cool temperate region. In the Kuriles we have no species which are limited to the Atlantic States in North America.

To give a better idea of the relative importance of these elements in the Kurile flora, the following table will show their proportions in terms of per cent., the varieties being taken as units, and the circumpolar species entirely discarded:—

Insular,	9.4		
N. E. Asiatic,	16.0		
N. + N. E. Asiatic,	3.4		
E. + N. E. Asiatic,	4.6		
E. Asiatic,	13.3		
N. + E. Asiatic,	2.1		
Himal. + E. Asiatic,	1.2		
Asiatic,			50.0
Eur. + E. Asia,	11.1		
Eur. + N. E. Asia,	4.3		
Europ.-Asiatic,			15.4
Europ.-Asia + N. W. Am.,	5.2		
Europ.-Asia + W. Am.,	3.4		
Intermediate,			8.6
W. Am. + E. Asia,	2.1		
W. Am. + N. E. Asia,	3.8		
N. W. Am. + E. Asia,	2.1		
N. W. Am. + N. E. Asia,	7.7		
N. Pacific,		15.7	
Am. (E.-W.) + N. E. Asia,	3.4		
Am. (E.-W.) + E. Asia,	6.9		
American,		10.3	
Amer.-Asiatic,			26.0

The table shows at once the great preponderance of the Asiatic species, the greater portion of which are restricted to the eastern and northeastern parts of Asia. Next in importance come the Americo-Asiatic, which divide themselves into two distinct groups: the American and north Pacific. The latter constitutes, by far, the more prominent part. It contains many interesting species, such as *Fritillaria kamtschatcensis*, *Boschniakia glabra*, *Rhododendron chrysanthum* and *kamtschaticum*, *Viola Langsdorffii*, *Claytonia sarmentosa*, *Lupinus Nootkatensis*, *Epilobium Behringianum* and *E. Bongardi*, *Primula cuneifolia*, *Gentiana auriculata*, *Cassiope lycopodioides*, *Erigeron salsuginosus*, *Lysichiton kamtschaticum*, *Saxifraga reflexa*, etc. The Europeo-Asiatic elements are also liberally represented. If the species which extend into northwestern America are included, they form about twenty-four per cent of the whole.

In the Kurile flora we have no additions of orders to make to the rich flora of Japan. As to the genera, there are six new additions, namely, *Parrya*, *Tetrapoma*, *Claytonia*, *Lupinus*, *Armeria* and *Dodecatheon*. These genera are found only in the northern Kuriles. None of them occur in the island of Saghalin.

As to the species, 54 are entirely new to Japan; and 12 species are represented under different varieties chiefly in the alpine regions of the main island. Of these, 13 are circumpolar species; 2 species and 1 variety are endemic (?); 5 species are Europeo-Asiatic, three of which extend into northwestern America; 6 are northern Asiatic; 17, northeastern Asiatic; 18, northern Pacific, and 4, American. With the exception of *Prunus Ceraseidos*, var. *kurilensis*, *Saxifraga bronchialis*, *Artemisia laciniata*, *Artemisia sericea*, *Carex macilenta* and *Carex vaginata*, the remaining 60 plants have thus far been found only in the islands lying northward of Urup! These facts clearly indicate that the vegetation of the southern Kuriles is very much like that of Japan (northern), while tha

of the northern approaches remarkably the flora of the Behring Sea region (northeastern Asiatic and northern Pacific).

In the southern Kuriles, for instance, we have such plants as the following, which show a strong affinity to the vegetation of the warmer climate:— *Ranunculus japonicus*, *Viola verecunda*, *Dianthus superbus*, *Hypericum erectum*, *Skimmia japonica*, *Ilex crenata*, *Evonymus alata*, *Rhus trichocarpa*, *Rhus Toxicodendron*, *Hydrangea scandens*, *Aralia racemosa*, var., *Acanthopanax ricinifolia*, *Leucothoë Grayana*, *Crawfurdia japonica* and *Bambusa kurilensis*.

Compared with the flora of Saghalin, we find a close resemblance between them in the vegetation of their respective southern portions. Both enjoy about the same climate and are under the same influences as the Japanese flora. Toward the north their contrast is striking, from the obvious reason of their proximity to different floral regions.

There are forty-three species in the Kurile flora which have not yet been found in Saghalin, but which are known to occur in Japan. Of these, seventeen plants grow also in Kamtschatka and adjacent districts. However small in number, consideration of these plants would be of some help to explain how far this chain of volcanic islands has been the means of introducing northern Asiatic plants into Japan. These seventeen species are as follows:—

Clematis fusca.
Barbarea vulgaris.
Stellaria florida.
Stellaria ruscifolia.
Trifolium Lupinaster.
Saxifraga Merkii.
Erigeron salsuginosus.
Cassiope lycopodioides.
Bryanthus taxifolius.
Primula cuneifolia.
Severtia tetrapetala.
Veronica Stelleri.
Pedicularis Chamissonis.
Polygonum viviparum.
Rumex Acetosa.
Microstylis monophyllos.
Equisetum limosum.

Some of these plants are of such wide distribution in the northern hemisphere that it is not fair to include them in our consideration of this question. Such plants as *Barbarea vulgaris*, *Trifolium Lupinaster*, *Bryanthus taxifolius*, *Polygonum viviparum*, *Rumex Acetosa*, *Microstylis monophyllos*, and *Equisetum limosum*, we may expect any time from Saghalin, as they are very common in all the surrounding countries. To the same category, I may add *Clematis fusca*. This reduces our list about one-half.

Stellaria florida, *Saxifraga Merkii*, and *Pedicularis Chamissonis* exist in Japan only as varieties in its alpine regions. This indicates that these plants were introduced into Japan a long time ago. The typical forms of *St. florida* and *Sax. Merkii* are now distributed in the northeastern part of Asia, extending from the Baikal district to Kamtschatka: and *Ped. Chamissonis* is found in Alaska, the Aleutian Islands and Kamtschatka. Their presence in the northern Kuriles in the present day does not necessarily prove that the species were introduced into Japan through this channel. It may simply indicate that they have been introduced here in recent times from Kamtschatka. The nature of the geology and general vegetation of these islands supports the latter view. According to Professor Milne, as I have stated before, all the northern Kuriles are of very recent formation, and "at the time when Japan was colonized, these stepping stones were probably without existence."

The scanty vegetation which we find in these northern islands is mostly composed of plants growing in Kamtschatka and the Aleutian Islands. The greater part of them are not yet known to come down to the southern Kuriles. A few plants, which are decidedly characteristic of northern Japan and the southern Kuriles, have also been found in some of the smaller islands north of Urup. *Petasites japonica*, for instance, is said to extend as far north as the island of Matua, and *Bambusa kurilensis* and *Taxus cuspidata*, to Ketoy. Thus it seems that these northern Kuriles are now in the stage of receiving their vegetation from both Kamtschatka and the southern Kuriles. Doubtless

many of these Kamtschatkan plants will in the future reach the northern shores of Japan, probably through the agency of currents and migratory birds. Of such, *Stellaria ruscifolia*, *Swertia tetrapetala*, and *Erigeron salsuginosus* (?), from their restricted range of distribution in the northeastern and eastern coasts of Yezo, would form good examples.

From these observations, I agree with Professor Milne in the opinion that at the time of the last great southerly migration of the rich polar flora, Japan received her portion mostly through the island of Saghalin, and but little, if any, through the then uncompleted chain of the Kurile Islands.

DICOTYLEDONES.

POLYPETALÆ.

RANUNCULACEÆ.

1. **Clematis fusca**, Turcz. in Bull. de la Soc. des Natur. de Mosc. (1840), p. 60; Ledeb. Fl. Ross. I, p. 725; Max. Mél. Biol. IX, p. 587; Fr. & Sav. Enum. II, p. 262.

Habitat. Northern *Kuriles!* (Turcz.).[1]

The plant is strictly northeastern Asiatic in its distribution. It grows in swampy places throughout eastern Siberia bordering the Ochotsk Sea, descending southward on the continental side as far as southern Manchuria; while on the insular side it was found to come south as far as the vicinity of Hakodate in Yezo. The plant has not yet been recorded from Saghalin.

According to Franchet & Savatier, the plants found growing around Hakodate belong to the var. *mandshurica*, Regel (Fl. Uss. p. 2, t. 2, f. 1). The plants which I have collected at Tokoro in the province of Kitami, and also at Horomui near Sapporo, have characters more nearly approaching that variety than any of the others established by Regel. But they differ in some points, which are easily noticeable. In the Yezo plants the flowers are also on both the terminal and axillary peduncles, and are provided with two opposite bracts; but they are always solitary, and the bracts, which are broadly ovate, obtuse, and often 2–3 lobed, are placed on the peduncle a little above the middle.

2. **Clematis alpina**, Miller; DC. Prod. I, p. 10. *Atragene alpina*, L.; Max. Mél. Biol. IX, p. 603; Turcz. Fl. Baic.-Dahur. I, p. 25. *Atr. alpina*, L., var. *ochotensis*, Reg. & Til. Fl. Ajan. p. 20. *Atr. platysepala*, Trautv. & Mey. Fl. Ochot. p. 5.

Hab. *Kurile Islands* (*ex* Turcz.). *Etorofu*, in shady woods near Furubetsu.

This extremely variable species is widely distributed in Europe, northern Asia and Japan; and also in the Rocky Mountain region of North America. The Japanese plants, especially those which grow in the cold shady woods of Yezo and the Kuriles, correspond exactly to those collected in eastern Siberia and Kamtschatka, described as var. *ochotensis* by Regel and Tiling.

The American form (*C. alpina*, var. *occidentalis*, A. Gray, in Powell's Geol. of Black Hills of Dakota, p. 531) can scarcely be distinguished from some of the Old World plants, except, perhaps, as has been pointed out by Dr. Gray, by a greater tendency of its petals to staminody,— a character which is very poorly developed in the European plant, but which is seen more and more marked in the plants growing eastward.

[1] The mark ! placed after a locality of a plant which was not collected by myself, indicates that the original specimen of the plant thus referred to has been seen by Prof. C. J. Maximowicz in the Herbaria of St. Petersburg.

3. **Thalictrum aquilegifolium**, L. Sp. p. 547; Ledeb. Fl. Ross. I, p. 65; Regel, Thalic. p. 10; Lecoyer, Monog. Thalic. p. 75; Fr. & Sav. Enum. I, p. 3.

Hab. Kurile Islands (*fide* Regel).

Distribution. Europe, middle and northern Asia, eastward to Kamtschatka, Saghalin and Japan.

4. **Thalictrum minus**, L. Sp. p. 546; Lecoyer, Monogr. Thalic. p. 124, t. v, f. 2–4.

Var. **elatum**, Lecoyer, *l. c.* p. 127. *Th. Kemense*, Fr. Fl. Halland, II, p. 94; Ledeb. Fl. Ross. I, p. 13; Regel, Thalic. p. 36. *Th. elatum*, Murr. in Trautv. & Mey. Fl. Ochot. p. 6. *Th. Kemense*, Fr., var. *stipellatum*, C. A. Mey. in Max. Prim. Fl. Amur. p. 16. *Th. hypoleucum*, Sieb. & Zucc. Fam. Nat. II. 306. *Th. minus*, L., var. *Kemense*, Trelease, Proc. Bost. Soc. N. H. XXIII, p. 300.

Hab. Kurile Islands (*fide* Regel). *Etorofu*, at Shana and Shibetoro.

This variety is also found throughout Japan, but is especially common towards the north, where it attains its greatest size in fertile valleys.

Var. **nanum**, Lecoyer *l. c.* p. 127. *Th. minus*, var. *fœtidum*, Hook. f. & Thoms. in Hook. Fl. Brit. Ind. I, p. 14.

Hab. Shikotan, on exposed hillsides facing the harbor.

Our plant is about a foot and a half in height with a stem bent in a somewhat zigzag way. Its leaflets are very small, $\frac{1}{3}$-$\frac{1}{2}$ inch in length, and glandular-pubescent beneath. The present variety is very much rarer in Japan than the above, growing mostly in the alpine districts. It is not yet known from Saghalin, Kamtschatka and Eastern Siberia.

The species is very widely distributed in Europe, Africa, Asia and Alaska.

5. **Anemone parviflora**, Michx. Fl. Bor.-Am. I, p. 319; Ledeb. Fl. Ross. I, p. 16; Schlecht. in Linnæa VI, p. 574.

Hab. Kurile Islands (Merk. *ex* Schlecht.).

Distrib. Arctic and northern temperate regions of North America from Labrador to Alaska, descending in the Rocky Mountains to Colorado; Aleutian Islands, Kamtschatka and Kurile Islands.

6. **Anemone debilis**, Fisch.; Turcz. in Bull. Mosc. XXVII, p. 274; Max. Mél. Biol. IX, p. 607; Fr. & Sav. Enum. II, p. 265. *A. ranunculoides*, var. *gracilis*, Schlecht. in Linnæa VI, p. 574. *A. cærulea*, var. *gracilis*, Ledeb. Fl. Ross. I, p. 14. *A. gracilis*, F. Schmidt Fl. Sach. p. 102.

Hab. Etorofu, at Furubetsu.

Distrib. Japan, Saghalin, northeastern Manchuria and Kamtschatka.

The plants which are found throughout northern Japan correspond exactly to the typical specimens from Kamtschatka and Saghalin. Those which were collected by Maximowicz in southern Japan, and which he considers as a variety of this species, have the leaves somewhat resembling those of *Anemone umbrosa*, though considerably smaller.

There are a few specimens in the Gray Herbarium labelled *A. umbrosa*, which were collected by W. P. Blake in "N. Japan." A similar specimen was collected in the vicinity of Sapporo. They have certainly a striking resemblance to the Ussuri specimen of *A. umbrosa* in the shape and proportion of the leaves and flowers, and in the nature of the

pubescence. The only points of difference between them, which I can find in the few specimens before me, are that the sepals are perfectly smooth on both sides in the Japanese plant, and that the peduncles are shorter than the leaves. The ovaries are still too young to show decidedly whether they are sessile or stipitate. They are covered with silvery appressed hairs; and the styles are elongated, cylindrical, smooth and erect. Doubtless the plant is much more closely related to *A. umbrosa* than to any other species. The character of its ripened carpels would settle the point, whether it is to be considered as a variety of that species or as distinct.

7. **Anemone narcissiflora**, L. Sp. p. 542; Ledeb. Fl. Ross. I, p. 18.—Var. **villosissima**, DC. Prodr. I, p. 22; Regel, Pl. Radd. I, p. 18; F. Schm. Fl. Sach. p. 104.

Hab. Etorofu, in an exposed moist field near Rubetsu.

Distrib. In the arctic and alpine regions of Europe and Asia, extending to Alaska, and the Rocky Mountains.

8. **Ranunculus japonicus**, Langsd.; Fisch. in DC. Prodr. I, p. 38; Max. Fl. As. Or. Fragm. I, p. 3; Forbes & Hemsley, Index Fl. Sin. p. 14. *R. ternatus*, DC., etc. (not Thunb.). *R. Sieboldi*, Miq. Prol. Fl. Jap. p. 193. *R. Vernyi*, Fr. & Sav. Enum. I, p. 8, II, p. 266.

Hab. Etorofu, at Shana.

The plant is closely related through some of the allied species growing on the continental side of Asia to *R. pennsylvanicus* of North America, of which, by a high authority, it is considered a variety.

However variable our plant is in many of its minor characters, incident to its great range of stations from the roadside ditch to the cold wet mountain woods, extending from the Loo Choo Islands to the Kuriles, yet there are some important characters which are constant at least within our insular limits. In these important characters, it differs distinctly from the typical *Ranunculus pennsylvanicus*.

In the latter, the akenes are provided with short, stout, and straight or slightly curved beaks, and are arranged in oblong or cylindraceous heads; and the petals are small, not surpassing the reflexed calyx. In *R. japonicus*, the akenes are provided with beaks which are attenuated and uncinate or subuncinate at the tip, and broad and flat at the base; they are arranged in globose heads; and the petals are larger, surpassing the recurved calyx. Considering all characters, our plant is more nearly related to *R. hispidus*, as characterized by Dr. Gray in his Revision of the N. Am. Ranunculi (Proc. Am. Acad. XXI, p. 375), than to *R. pennsylvanicus*, L. f.

9. **Ranunculus acris**, L.; Ledeb. Fl. Ross. I, p. 41; Reg. & Til. Fl. Ajan. p. 32; Reg. Fl. Uss. p. 7. *R. japonicus*, Thunb. Trans. Linn. Soc. III, p. 337. *R. propinquus*, C. A. Mey. in Ledeb. Fl. Alt. III, p. 332; Ledeb. Fl. Ross. I, p. 41. *R. propinquus*, var. *hirsutus*, A. Gray, Bot. Jap. p. 378.

Hab. Etorofu, at Tsurubetsu, Shana and Shibetoro.

Distrib. Europe, northern Africa, northern and middle Asia, Japan, Greenland? and Newfoundland?

10. **Trollius patulus**, Salisb. Trans. Linn. Soc. VIII, p. 303; Ledeb. Fl. Ross. I, p. 50; Reg. & Til. Fl. Ajan. p. 36. *Trollius japonicus*, Miq. Prol. Fl. Jap. p. 194.
Var. **genuinus**, l. **pedunculatus**, Reg. & Til. *l. c.*

Hab. Kurile Islands (Reg. & Til.). *Etorofu*, along a stream in a sheltered valley near Furubetsu, and also at Shana and Shibetoro.

Distrib. Middle and northern Japan, Saghalin, Kamtschatka, Eastern Siberia, Dahuria and Caucasus.

My Etorofu specimens coincide exactly with one collected by Stewart in Kamtschatka labelled as "*Trollius patulus*, Salisb., var. *genuinus*, lns. 2. *pedunculatus*, teste Regel."

11. Coptis trifolia, Salisb. Trans. Linn. Soc. VIII, p. 305; Ledeb. Fl. Ross. I, p. 52; Torr. & Gray, Fl. N. Am. I, p. 28; Fr. & Sav. Enum. I, p. 10.

Hab. Etorofu, at Furubetsu, and Nobori.

Distrib. From eastern Russia to Manchuria and Kamtschatka, Saghalin and northern and middle Japan; in North America, spreading from Alaska to Labrador and Greenland, and descending on the Atlantic side to Pennsylvania; also in Iceland.

12. Aconitum Fischeri, Reich. Ill. Sp. Acon. Gen. fol. 22, t. 22; Regel, Conspec. Acon. p. 150; F. Schm. Fl. Sach. p. 107; Fr. & Sav. Enum. I, p. 12; Forbes & Hemsley, Index Fl. Sin. p. 20.

Hab. Etorofu, on hillsides at Shana, and Shibetoro.

Distrib. Kamtschatka, Japan, Saghalin, Manchuria and China.

13. Cimicifuga simplex, Wormsk. *ex* Fisch. in DC. Prodr. I, p. 64.—Var. **ramosa**, Max. in Fr. & Sav. Enum. I, p. 13. *C. simplex*, Max. Prim. Fl. Amur. p. 29; F. Schm. Fl. Sach. p. 109. *C. fœtida*, var. *simplex*, Reg. Fl. Uss. p. 12, Pl. Radd. I, p. 122.

Hab. Shikotan. Etorofu, at Arimoi and Shibetoro.

Distrib. Dahuria, Manchuria to Kamtschatka, Saghalin, and northern and middle Japan.

FUMARIACEÆ.

14. Corydalis ambigua, Cham. & Schlecht. in Linnæa I, p. 558; Ledeb. Fl. Ross. I, p. 101; Max. Prim. Fl. Amur. p. 37; Regel, Pl. Radd. I, p. 137; F. Schm. Fl. Sach. p. 110.

Hab. Etorofu.

I have not seen the plant myself in the field, but its globular rootstocks used as food there by the Aino inhabitants were shown to me. They call them *toma*, and cook them by boiling with a certain kind of clayey earth, found on the beach, to remove the bitter taste. The rootstock is exactly the same as that of the Yezo plant, which is also called by the same name and used for the same purpose.

Distrib. Kamtschatka and its adjacent islands, northeastern Manchuria, Saghalin and northern Japan; and also in northern Siberia about the Jenisei (*ex* Ledeb.).

15. Corydalis ochotensis, Turcz. in Ledeb. Fl. Ross. I, p. 103; Forbes & Hemsley, Index Fl. Sin. p. 37 ? *C. sibirica*, var. *ochotensis*, Reg. Pl. Radd. I, p. 143.

Hab. Kurile Islands! (*ex* Max.).

Distrib. Ochotsk region and Kuriles; as vars. *Raddeana* and *mandshurica* Max., in Manchuria, northern China, and in Japan (Kiusiu to northern Yezo).

CRUCIFERÆ.

16. Parrya macrocarpa, R. Br. in Parry's First Voyage, p. 270; Hook. Fl. Bor.-Am. I, p. 47, t. 15; Ledeb. Fl. Ross. I, p. 131; Hook. & Anders., Hook. Fl. Brit. Ind., I, p. 131. *Parrya nudicaulis*, Regel, Pl. Radd. I, p. 176.

Hab. *Urup!* (*ex* Max.).

Distrib. Arctic Europe, Asia and North America; in the alpine regions of central Asia and western North America.

17. **Barbarea vulgaris**, R. Br. Hort. Kew. ed. 2, IV, p. 109; Ledeb. Fl. Ross. I, p. 114; Regel, Pl. Radd. I, p. 153; Torr. & Gray, Fl. N. Am. I, p. 75; Fr. & Sav. Enum. I, p. 32, II, p. 278.

Hab. *Etorofu*, at Rubetsu.

Distrib. Europe, northern and southern Africa, northern and temperate Asia to Alaska and western North America. Naturalized in the eastern United States.

18. **Arabis Stelleri**, D.C. Syst. II, p. 242; Ledeb. Fl. Ross. I, p. 122.—Var. **japonica**, F. Schm. Fl. Sach. p. 111; Fr. & Sav. Enum. I, p. 33, II, p. 278. *Arabis alpina* (?), var. *japonica*, A. Gray, Pl. Jap. p. 307. *A. japonica*, A. Gray, Bot. Jap. p. 381.

Hab. *Etorofu*, at Rubetsu.

Distrib. Saghalin, northern and middle Japan, Corea, Manchuria, Kamtschatka to the Aleutian Islands.

19. **Arabis lyrata**, L. Sp. p. 665; Torr. & Gray, Fl. N. Am. I, p. 81; DC. Prodr. I, p. 146; A. Gray, Pl. Jap. p. 307; Fr. & Sav. I, p. 33.

Hab. *Shikotan*, on rocky cliffs along the beach.

Distrib. Middle and northern Japan, and in North America: Canada to Virginia and Lake Superior, and westward in the Pacific regions, as var. *occidentalis*, Watson, *MS.* (*A. ambigua*, DC., in part).

20. **Arabis ambigua**, DC. Syst. II, p. 231; Ledeb. Fl. Ross. I, p. 120; Trautv. & Mey. Fl. Ochot. p. 14; Reg. & Til. Fl. Ajan. p. 46. *A. kamtschatica*, Fisch. in DC. Syst. II, p. 231 (as *A. lyrata*, β.); Ledeb. Fl. Ross. II, p. 121. *A. petræa*, β–δ, Regel, Pl. Radd. I, p. 166.

Hab. *Kurile Islands* (*ex* DC.). *Urup !* (*ex* Max.).

Distrib. Ochotsk region, northeastern Manchuria, Saghalin, Kurile Islands and Kamtschatka.

Probably this plant does not differ from Dr. S. Watson's var. *occidentalis* of *A. lyrata*. The specimens from Alaska and the Aleutian Islands, and also those which were collected in Kamtschatka by C. Wright, and which were variously referred to *A. ambigua* and *kamtschatica*, are all considered by Dr. Watson as belonging to his variety of *A. lyrata*.

21. **Arabis perfoliata**, Lam. Dict. I, p. 219; Fr. & Sav. Enum. I, p. 34. *Turritis glabra*, L. Sp. p. 666; Ledeb. Fl. Ross. I, p. 116.

Hab. *Etorofu*, at Arimoi.

Distrib. Europe, temperate Asia, and N. America (W. and E.).

22. **Cardamine pratensis**, L. Sp. p. 656; Ledeb. Fl. Ross. I, p. 125.—Var. **prorepens**, Max. Mél. Biol. IX, p. 6. *C. prorepens*, Fisch. in DC. Syst. II, p. 256; Ledeb. *l.c.* p. 125.

Hab. *Kurile Islands!* (Herb. Fisch.)

Distrib. Eastern Siberia, Dahuria, Manchuria, and Kurile Islands.

The species is circumpolar in its distribution.

23. **Draba hirsuta**, Turcz. in Bull. Mosc. 1840, p. 64; Ledeb. Fl. Ross. I, p. 755.

Hab. *Kurile Islands* (*ex* Turcz.).

"(Leucodraba) caulibus ramosis foliosis cum pedunculis foliisque pube stellata et pilis simplicibus incanis, foliis oblongis ovatisve acutis dentatis, petalis oblongis calyce pubescente duplo majoribus, siliculis ovato-oblongis rectis pedicellos adæquantibus pube stellata incanis calyce persistente stipatis, stylo brevissimo.

"Calyce persistente et siliculis rectis brevioribus a proxima *D. confusa*, Ehrh. (*D. incana*, L.) distinguitur."

24. Draba borealis, DC. Syst. II, p. 342.—Var. **kurilensis**, F. Schm. Fl. Sach. p. 114; Max. Mél. Biol. IX, p. 609; Fr. & Sav. Enum. II, p. 282. *Odontocyclus kurilensis*, Turcz. in Bull. Mosc. 1840, p. 65; Ledeb. Fl. Ross. I, p. 756.

Hab. Kurile Islands! (*ex* Turcz., Max., etc.) *Etorofu*, on moist cliffs at Tsurubetsu. *Shikotan*, on rocky cliffs.

My Shikotan specimens correspond exactly with the Hakodate specimens in every character. The Etorofu plant, on account of its moist habitat, is taller and weaker, but coincides perfectly with the plant under consideration in all its essential characters. Its flowering stalk is about 28 cm. long and ascending; generally about eight cauline leaves are distantly arranged quite well up to the inflorescence, and they are beset with bifurcate or stellate hairs; the upper leaves are ovate, sessile, obtuse or subacute; the lower, obovate, obtuse and tapering to the petiole. The petals are about twice as long as the sepals. The fruits are immature, smooth (very young ones slightly hairy), more or less twisted, and thickened here and there along the margin with callous spots; the styles are thick and short.

Regel & Tiling in their Flornla Ajanensis, p. 59, describe a variety of *Draba borealis* from the Kurile Islands under the name of var. *foliosa*, with *D. unalaschkiana*, DC., as a synonym. Prof. Maximowicz kindly informs me that the variety was "founded on one bad specimen, which looks different enough, but indeed nearer to *D. unalaschkiana*." In the Gray Herbarium, I have found a flowering specimen of a *Draba* from Urnp sent by "Grisebach or Bunge," under the name of *D. unalaschkiana*. Compared with our plant, it has larger flowers, and hairy sepals; and some of its cauline leaves are conspicuously few-dentate, the teeth spreading. It corresponds very well with the specimens from Alaska, the Alentian Islands and northern British Columbia, having contorted pubescent pods. For the present, in the absence of good specimens from the Kurile Islands, it is hard to decide, whether the var. *foliosa*, Reg. & Til., and *D. unalaschkiana*, DC., are really the same plant or not. *D. hirsuta*, Turcz., may most likely come also under the same species.

Our present variety has been found in Yezo, Saghalin, and the Kurile Islands. The species has its range of distribution in northeastern Asia and northwestern America.

25. Draba gelida, Turcz. Cat. Pl. Baic.-Dah. n. 131, Fl. Baic.-Dah. I, p. 132. *D. Wahlenbergii*, var. *gelida*, Reg. Pl. Radd. I, p. 189.

Hab. Kurile Islands (*fide* Turcz.).

Distrib. Alpine and subalpine districts of Dahuria, and the Altai and Baikal regions.

26. Tetrapoma barbaraefolium, Turcz. Fl. Baic.-Dah. I, p. 147; Ledeb. Fl. Ross. I, p. 161. *Camelina barbareaefolia*, DC. Prodr. I, p. 201; Hook. Fl. Bor.-Am. I, p. 201.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Dahuria, Manchuria, and eastern Siberia; also in northwestern America.

27. **Capsella Bursa-pastoris**, Moench. Meth. p. 271; Ledeb. Fl. Ross. I, p. 199; Fr. & Sav. Enum. I, p. 38.

Hab. *Etorofu*, common about the settlements and by the roadsides.

VIOLACEÆ.

28. **Viola Selkirkii**, Goldie in Edin. Phil. Journ. VI, p. 319; A. Gray, Bot. Jap. p. 382; Max. Mél. Biol. IX, p. 730. *V. kamtschatica*, Ging. in Linnæa I, p. 406. *V. umbrosa*, Fries, Novit. p. 271; F. Schm. Fl. Sach. p. 115. *V. Selkirkii*, var. *glabra*, Miq. Prol., p. 85.

Hab. *Etorofu*, at Furubetsu.

Distrib. Northern Europe; Siberia, Dahuria, Manchuria, northern China, Japan, Saghalin, Kamtschatka; British Columbia to New Brunswick and New York.

29. **Viola Langsdorffii**, Fisch. in DC. Prodr. I, p. 296; Ledeb. Fl. Ross. I, p. 250; Max. Mél. Biol. IX, p. 741. *Viola mirabilis*, var. *Langsdorffii*, Regel, Pl. Radd. I, p. 240.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Eastern Siberia, Saghalin, Yezo, Kamtschatka, the Aleutian Islands, Alaska, British Columbia to Oregon.

30. **Viola canina**, L., var. **acuminata**, Regel, Pl. Radd. I, p. 247; Max. Mél. Biol. IX, p. 746. *V. acuminata*, Ledeb. Fl. Ross. I, p. 252; Max. Prim. Fl. Amur. p. 50. *V. micrantha*, Turcz. in Bull. Mosc. V, p. 183, X, p. 148. *V. laciniosa*, A. Gray, Pl. Jap. p. 308.

Hab. *Etorofu*, at Rubetsu.

Distrib. Middle and northern Japan, Saghalin, Manchuria, China and Corea; also in Dahuria.

This species is very widely distributed in the temperate regions of the northern hemisphere.

31. **Viola verecunda**, A. Gray, Bot. Jap. p. 382; Max. Mél. Biol. IX, p. 750; Fr. and Sav. Enum. II, p. 648; Forbes & Hemsl. Index Fl. Sin. p. 56.

Hab. *Etorufu*, at Rubetsu.

Distrib. Throughout Japan; China and Formosa.

CARYOPHYLLACEÆ.

32. **Dianthus alpinus**, L., var. **repens**, Regel, Pl. Radd. I, p. 286. *D. repens*, Willd. Sp. II, p. 681; Ledeb. Fl. Ross. I, p. 281; Torr & Gray, Fl. N. Am. I, p. 195; Reg. & Til. Fl. Ajan. p. 63.

Hab. *Urup!* (*ex* Max.).

Distrib. Eastern Siberia along the whole coast of the Ochotsk Sea, Kamtschatka to Alaska.

33. **Dianthus superbus**, L. Sp. p. 589; Ledeb. Fl. Ross. I, p. 285; Fr. & Sav. Enum. I, p. 46.

Hab. *Shikotan*, in grassy places along the beach. *Etorofu*, at Tsurubetsu.

Distrib. Europe to Manchuria, China, Japan, and Saghalin.

34. **Lychnis affinis**, Vahl, Fr. Mant. III, p. 36. *Melandryum involucratum*, var. *affine*, Rohrb. in Linnæa XXXVI, p. 216; Regel, Pl. Radd. I, p. 319.

Hab. *Urup!* (*ex* Max.).

Distrib. Arctic Europe, Greenland and Labrador, and in northeastern Asia about the Ochotsk Sea.

35. **Cerastium semidecandrum**, L., var. **herbaceo-bracteatum**, Fenzl in Ledeb. Fl. Ross. I, p. 406; Regel, Pl. Radd. I, p. 431; Max. Mél. Biol. IX, p. 52.

Hab. *Kurile Islands!* (herb. Fischer).

Distrib. Europe, southern Japan. Not yet found in the intervening countries.

36. **Cerastium vulgatum**, L., var. **glandulosum**, Koch, Syn. ed. I, p. 134; Regel, Pl. Radd. I, p. 432; Max. Mél. Biol. IX, p. 52; Fr. & Sav. Enum. I, p. 50, II, p. 295. *C. vulgatum*, var. *brachypetalum*, Fenzl in Ledeb. Fl. Ross. I, p. 408.

Hab. *Etorofu*, at Furubetsu.

Distrib. Japan, Saghalin, Kamtschatka, Manchuria, Dahuria, Siberia to Europe. According to Regel, also in Sitka.

Var. **grandiflorum**, Fenzl in Ledeb. Fl. Ross. I, p. 410; Reg. & Til. Fl. Ajan. p. 75. *C. alpinum*, var. *typicum*, lus. *grandiflorum*, Reg. Pl. Radd. I, p. 442.

Hab. *Kurile Islands!* (Max.).

Distrib. Arctic and alpine Europe, Baika land Eastern Siberia, the Aleutian Islands and Alaska.

37. **Cerastium alpinum**, L., var. **Beeringianum**, Regel, Pl. Radd. I, p. 435. *C. Beeringianum*, Cham. & Schlecht. in Linnæa I, p. 62; Hook. Fl. Bor.-Am. I, p. 105. *C. vulgatum*, var. *Behringianum*, Fenzl in Ledeb. Fl. Ross. I, p. 409.

Hab. *Kurile Islands* (herb. Fisch. *ex* Regel).

Distrib. Western North America in the Rocky Mountain regions and northward to arctic Alaska; Aleutian Islands, Kamtschatka, Eastern Siberia to the Baikal district.

Var. **Fischerianum**, Torr. & Gray, Fl. N. Am. I, p. 188; Regel, Pl. Radd. I, p. 438; Max. Mél. Biol. IX, p. 53. *C. Fischerianum*, Ser. in DC. Prodr. I, p. 419; F. Schm. Fl. Sach. p. 118.

Hab. *Etorofu*, at Tsurubetsu.

Distrib. Middle and northern Japan, Saghalin, Manchuria, Dahuria, Eastern Siberia, Kamtschatka, the Aleutian Islands, Alaska, Arctic America to Greenland.

38. **Stellaria media**, Vill.; Fenzl in Ledeb. Fl. Ross. I, p. 377; Max. Mél. Biol. IX, p. 42.

Hab. *Etorofu*, very common at Shana, Furubetsu and elsewhere.

39. **Stellaria radians**, L., Sp. p. 422; Fenzl in Ledeb. Fl. Ross. I, p. 378; Max. Prim. Fl. Amur. p. 59; F. Schm. Fl. Sach., p. 117; Max. Mél. Biol. IX, p. 44.

Hab. *Etorofu*, at Rubetsu and Shana.

Distrib. Eastern Siberia, Kamtschatka, Yezo, Saghalin, Manchuria, Dahuria, Baikal and Altai districts of Siberia.

40. **Stellaria florida**, Fisch., *ex* DC. Prod. I, p. 399; Fenzl in Ledeb. Fl. Ross. I, p. 385; Regel, Pl. Radd. I, p. 418; Max. Mél. Biol. IX, p. 46.

Hab. *Kurile Islands !* (*ex* Max.).

Distrib. Eastern Siberia about the Ochotsk Sea; Kamtschatka; and the alpine region of northern Manchuria and Dahuria. As var. *angustifolia*, Max., on the alpine summits of middle Japan.

41. **Stellaria Eschscholtziana**, Fenzl in Ledeb. Fl. Ross. I, p. 384; Regel, Pl. Radd. I, p. 418.

Hab. *Kurile Islands !* (herb. Fisch. *ex* Max.).

Distrib. Kamtschatka and its adjacent islands.

42. **Stellaria ruscifolia**, Willd.; Fenzl in Ledeb. Fl. Ross. I, p. 385; Regel & Til. Fl. Ajan. p. 74; Regel, Pl. Radd. I, p. 419; Max. Prim. Fl. Amur. p. 59, Mél. Biol. IX, p. 46.

Hab. *Shikotan*, on rocky cliffs along the harbor. *Etorofu*, at Tsurubetsu.

Distrib. Northeastern Manchuria, Eastern Siberia in the Ochotsk district; Kamtschatka; northeastern Yezo.

43. **Stellaria longifolia**, Muhl. in Willd. Enum. Berol. p. 679; Fenzl in Ledeb. Fl. Ross. I, p, 392; Regel, Pl. Radd. I, p. 406; Torr. & Gray, Fl. N. Am. I, p. 185; F. Schm. Fl. Sach., p. 118; Max. Mél. Biol. IX, p. 48.

Hab. *Kurile Islands!* (herb. Fisch.; and Mertens *ex* Max.).

Distrib. Subarctic and central Europe, eastward along the higher mountains of southern Siberia to Manchuria, Ochotsk district, Kamtschatka, Saghalin and Yezo; Aleutian Islands, Alaska to Oregon and Colorado, across British America and the lake region to Virginia.

44. **Stellaria yezoensis**, Max.! Mél. Biol. XII, p. 419. *S. pilosula*, Franchet in Bull. Soc. Philom. Paris, avril, 1888.

Hab. *Etorofu*, at Tsurubetsu.

Distrib. Yezo; in moist woods on both the western and eastern coasts, and northward to Nemuro.

45. **Arenaria lateriflora**, L.; Hook. Fl. Bor.-Am. I, p. 102, t. 36; Torr. & Gray, Fl. N. Am. I, p. 182. *Mœhringia lateriflora*, Fenzl, Ann. Mus. Wien, I, pp. 18 and 38; Ledeb. Fl. Ross. I, p. 371; Regel, Pl. Radd. I, p. 378; Max. Mél. Biol. IX, p. 35.

Hab. *Kurile Islands!* (herb. Fisch.). *Shikotan.* *Etorofu*, at Shana and Shibetoro.

Distrib. Arctic and cool temperate regions of the northern hemisphere.

46. **Arenaria peploides**, L., var. **oblongifolia**, Watson, Index, p. 97. *Honckenya oblongifolia*, Torr. & Gray, Fl. N. Am. I, p. 176. *H. peploides*, Ehrh., var. *oblongifolia*, Fenzl in Ledeb. Fl. Ross. I, p. 358; Regel, Pl. Radd. I, p. 336; Regel & Til. Fl. Ajan. p. 73; A. Gray, Pl. Jap. p. 309. *Ammodenia peploides*, Rupr.; Max. Mél. Biol. IX, p. 34.

Hab. *Etorofu*, at Arimoi and Shana.

Distrib. Coast regions of Yezo, Saghalin, Manchuria, Ochotsk district, Kamtschatka, Aleutian Islands, Alaska to Oregon.

PORTULACACEÆ.

47. **Claytonia sarmentosa**, C. A. Mey. in Mém. Soc. Nat. Mosc. VII. p. 137, t. 3; Fenzl in Ledeb. Fl. Ross. II, p. 149. *C. Chamissoi*, DC. Prodr. III, p. 361. *C. lanceolata*, Hook. & Arn. Bot. Beechey, p. 123 and 344.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Alaska and adjacent islands.

Turczaninow, in his Flora Baicalensi-Dahurica, I, p. 431, alludes in a note under *Claytonia arctica*, Adams, to a plant from the Kurile Islands, which was referred to *C. acutifolia* by Pallas. Judging from his descriptions, it seems to me that Pallas' plant may not be different from *C. sarmentosa*, var. *tenella*, Fenzl.

HYPERICACEÆ.

48. **Hypericum erectum**, Thunb.! Fl. Jap. p. 296; Miq. Prol. Fl. Jap. p. 147; Max. Mél. Biol. XI, p. 168. *H. attenuatum*, F. Schm. Fl. Sach. p. 119.

Hab. *Etorofu*, at Shana.

Distrib. Saghalin, Japan, China?

GERANIACEÆ.

49. **Geranium yesoense**, Fr. & Sav. Enum. II, p. 305; Max. Mél. Biol. X, p. 625. *G. erianthum*, A. Gray, Bot. Jap. p. 383 (Hakodate specimens)!

Hab. *Shikotan*, in grassy places on the beach. *Etorofu*, at Shana.

Distrib. Common along the coasts of Yezo, from Hakodate to Nemuro, and also on the Ishikari beach. The plant seems to be a genuine littoral species.

50. **Geranium erianthum**, DC. Prodr. I, p. 641; Torr. & Gray, Fl. N. Am. I, p. 206; Ledeb. Fl. Ross. I, p. 464; F. Schm. Fl. Sach. 120; Fr. & Sav. Enum. I, p. 69, II, p. 303; Max. Mél. Biol. X, p. 631.

Hab. *Etorofu*, at Rubetsu.

Distrib. Northern Japan; Saghalin; northeastern Manchuria; Eastern Siberia in the Ochotsk region; Kamtschatka and adjacent islands; northwestern North America.

51. **Oxalis Acetosella**, L. Sp. p. 433; Torr. & Gray, Fl. N. Am. I, p. 211; Ledeb. Fl. Ross. I, p. 482; F. Schm. Fl. Sach. p. 120; Fr. & Sav. Enum. I, p. 69.

Hab. *Etorofu*, in the vicinity of Furubetsu.

Widely distributed over the north temperate zone.

52. **Impatiens Nolitangere**, L. Sp. p. 938; DC. Prodr. I, p. 687; Ledeb. Fl. Ross. I, p. 481; Max. Prim. Fl. Amur. p. 71; F. Schm. Fl. Sach. p. 120; Fr. & Sav. Enum. I, p. 70.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Japan; Saghalin; Kamtschatka; Manchuria; Corea; northern China; and throughout northern Asia to Europe.

RUTACEÆ

53. **Skimmia japonica**, Thunb.! Fl. Jap. p. 62; Sieb. & Zucc. Fl. Jap. I, p. 127, t. 68; A. Gray, Bot. Jap. p. 383; F. Schm. Fl. Sach. p. 121; Fr. & Sav. Enum. I, p. 74.

Hab. *Etorofu*, at Furubetsu, Arimoi and Shibetoro.

Distrib. Japan, from the alpine woods of Kiusiu to the northern end of Yezo and to the southern Kuriles. It was also found in southern Saghalin.

ILICINEÆ

54. **Ilex crenata**, Thunb. Fl. Jap. p. 78; Sieb. & Zucc. Fl. Jap. Fam. Nat. I, n. 147; Fr. & Sav. Enum. I, p. 76; F. Schm. Fl. Sach. p. 122; Max. Mém. Acad. Pétersb. XXIX, pp. 21 and 331. *I. Thomsoni*, Hook. f. Fl. Brit. Ind. I, p. 602 (*fide* Max.).

Hab. *Etorofu*, at Arimoi and Shibetoro.

The Kurile plants are all small straggling shrubs with roundish-obovate leaves (14–16 mm. in length). The species is found from southern Saghalin southward through the entire length of Japan, recurring in the temperate region of eastern Himalaya.

55. **Ilex rugosa**, F. Schm. Fl. Sach. p. 122, t. 3, f. 1–7; Max. Mém. Acad. Pétersb. 7e Ser. XXIX, p. 47; Fr. & Sav. Enum. II, p. 311.

Hab. *Etorofu*, at Furubetsu, Shana, and Shibetoro.

Distrib. Saghalin; northern and middle Japan.

CELASTRACEÆ.

56. **Evonymus alata**, Thunb. Fl. Jap. p. 98; Miq. Prol. p. 18; Fr. & Sav. Enum. I, p. 78; Max. Mél. Biol. XI, p. 196; F. Schm. Fl. Sach. p. 121.

Hab. *Etorofu*, at Arimoi.

Distrib. Japan; Saghalin; southern Manchuria; northern and middle China; Corea.

A small shrub about a foot high with brownish corky protuberances in more or less irregularly interrupted rows; leaves glabrous beneath; peduncle only one-flowered, 6–6½ mm. long; two opposite minute brownish bracts toward the base. I consider the plant to be of the typical form. The corky ridges, though not well developed, and the smoothness of the leaves exclude it from vars. *subtriflora* and *pubescens*.

57. **Evonymus macroptera**, Rupr. in Bull. Phys. Math. XV, Pl. Maack, n. 21; Max. Fl. Amur. p. 75, Mél. Biol. XI, p. 184; F. Schm. Fl. Sach. p. 121.

Hab. *Etorofu*, at Nobori and Shana.

Distrib. Middle and northern Japan; Saghalin; eastern Manchuria.

SAPINDACEÆ.

58. **Acer pictum**, Thunb. Fl. Jap. p. 161; Miq. Prol. p. 19; Fr. & Sav. Enum. I, p. 87; Max. Mél. Biol. X, p. 599. *A. Mono*, Max. Prim. Fl. Amur. p. 68; F. Schm. Fl. Sach., p. 119.

Hab. *Etorofu*, at Furubetsu and Nobori.

Distrib. Japan; Saghalin; Manchuria; northeastern China; Corea.

59. **Acer spicatum**, Lam. Dict. II, p. 381; Torr. & Gray, Fl. N. Am. I, p. 246.—Var. **ukurunduense**, Max. Prim. Fl. Amur. p. 65; F. Schm. Fl. Sach. p. 119; Fr. & Sav. Enum. I, p. 88; Max. Mél. Biol. X, p. 594. *Acer ukurunduense*, Trautv. & Mey. Fl. Och. p. 24.

Hab. *Etorofu*, at Furubetsu and Nobori.

Distrib. Middle and northern Japan; Saghalin, eastern Manchuria and the Ochotsk district.

ANACARDIACEÆ.

60. **Rhus trichocarpa**, Miq.! Prol. Fl. Jap. p. 16; Fr. & Sav. Enum. I, p. 95; Engler in DC. Monog. Phanerog. IV, p. 379.

Hab. *Etorofu*, on the Rubetsu side of Nobori.

Distrib. Throughout Japan; Corea.

61. **Rhus Toxicodendron**, L., var. **radicans**, Torr. Fl. U. S. p. 324; Torr. & Gray, Fl. N. Am. I, p. 218; Fr. & Sav. Enum. I, p. 93; F. Schm. Fl. Sach. 123; Gray, Bot. Jap. p. 384; Engler, DC. Monog. IV, p. 394.

Hab. *Shikotan*. *Etorofu*, at Furubetsu.

Distrib. Very widely distributed in North America from the Atlantic coast to the Pacific. Also in southern Saghalin and Japan: from Yezo to Shikoku.

LEGUMINOSÆ.

62. **Thermopsis fabacea**, DC. Prodr. II, p. 99; Ledeb. Fl. Ross. I, p. 511; A. Gray, Bot. Jap. p. 385; F. Schm. Fl. Sach. p. 123; Miq. Prol. p. 230; Fr. & Sav. Enum. I, p. 94; Forbes & Hemsley, Index Fl. Sin. p. 150. *Sophora fabacea*, Pall. Sp. Astrag. p. 122, t. 90, f. 2.

Hab. *Kurile Islands* (*ex* Pallas). *Etorofu*, near Tsurubetsu. *Shikotan*.

Distrib. Kamtschatka; Saghalin; Japan to Loochoo; Corea; Manchuria; China as south as Amoy. The plant is restricted to the littoral region.

63. **Lupinus nootkatensis**, Donn, Cat. Hort. Cant.; Torr. & Gray, Fl. N. Am. I, p. 375; Ledeb. Fl. Ross. I, p. 512; Watson, Rev. Lup. p. 524. *L. macrorhizos*, Georgi, Beschr. d. Russ. R. III, 4, p. 1162.

Hab. *Kurile Islands* (Merk, *fide* Georgi).

Distrib. From Vancouver to northern Alaska; Aleutian Islands, to the Kuriles.

64. **Trifolium Lupinaster**, L. Sp. p. 766; Ledeb. Fl. Ross. I, p. 551; Max. Prim. Fl. Amur. p. 79; Fr. & Sav. Enum. I, p. 96, II, p. 324; Forbes & Hemsley, Index Fl. Sin. p. 155.

Hab. *Shikotan*, in grassy places along the beach. *Etorofu*, at Shana.

Distrib. Kamtschatka to northern and middle Japan, Manchuria, northeastern China, Mongolia, westward through Siberia to the central part of Russia in Europe.

65. **Oxytropis Pumilio**, Ledeb. Fl. Ross. I, p. 589; Bunge, Sp. Gen. Oxytrop. p. 115. *Astragalus Pumilio*, Pall. Sp. Astr. p. 67, t. 55.

Hab. *Kurile Islands* (Merk, *ex* Pallas).

The plant has not yet been found elsewhere. All that we know of it is from the descriptions and figures given by Pallas. Bunge observes that all the characters of this plant agree very well with those of *O. revolutum*, Ledeb., with the exception of its very short stalk and smaller bracts. As its ripened fruits were not collected, the important character of the legume and its stipe is still wanting to settle satisfactorily its true position among the most closely related species.

66. **Vicia unijuga**, Al. Braun, App. Ind. Sem. Hort. Berol. 1853, p. 12; Max. Mél. Biol. IX, p. 65. *Orobus lathyroides*, L.; Ledeb. Fl. Ross. I, p. 688; F. Schm. Fl. Sach. p. 124. *O. japonicus*, Sieb. Toelicht. tot de ontd. v. Vries, p. 155. *Lathyrus Messerschmidii*, Fr. & Sav. Enum. I, p 106.

Hab. *Etorofu*, in roadside thickets in the vicinity of Shana.

The plant is very common on plains and in thickets in Yezo and the northern and middle provinces of the main island of Japan. Towards the south it is found only in alpine woods. It also grows in Saghalin, Manchuria, Corea and northern China, extending westward to the Altai region of Siberia.

67. **Vicia Cracca**, L.; Ledeb. Fl. Ross. I, p. 674; Torr. & Gray, Fl. N. Am. I, p. 270; Max. Prim. Fl. Amur. p. 82; Miq. Prol. p. 238.

Hab. *Shikotan*. *Etorofu*, at Tsurubetsu, and Shana.

This variable species is widely distributed throughout the temperate and subarctic regions of the northern hemisphere.

68. **Vicia amoena**, Fisch. in DC. Prodr. II, p. 355; Ledeb. Fl. Ross. I, p. 672; Max. Prim. Fl. Amur. p. 81; F. Schm. Fl. Sach. p. 124; Fr. & Sav. Enum. I, p. 104, II, p. 381.

Hab. *Etorofu*, in thickets around Arimoi.

In Saghalin, the plant is said to be common on the whole western coast south of Dui. It is also widely distributed in the island of Yezo, and in the northern and middle parts of the main island of Japan. On the continent, it spreads through the entire length of Siberia from the Ural region to Kamtschatka, and extends southward to Corea and northern China.

69. **Lathyrus maritimus**, Bigel. Fl. Bost. 2nd. ed. p. 268; Torr. & Gray, Fl. N. Am. I, p. 273; Miq. Prol. p. 233; F. Schm. Fl. Sach. p. 124; Max. Mél. Biol. IX, p. 60. *Pisum maritimum*, L.; Ledeb. Fl. Ross. I, p. 661.

Hab. *Urup!* (*ex* Max.). *Shikotan*, in sandy beaches at the foot of cliffs. *Etorofu*, at Rubetsu and Shana.

Very widely distributed in arctic and temperate Europe, Asia and North America. The most southern locality for this plant in the northern hemisphere, so far as I am aware, is in Japan, where it comes down to the vicinity of Nagasaki (about 32° N. lat.).

According to Hooker, a similar plant was collected at Cape Tres Montes in Patagonia by Darwin. From the wild and desolate nature of the place, and from the utter absence of other introduced plants, he concludes that it could not have been imported into this locality, "one of the most remote and little visited spots of the American continent." Fl. Antarc., II, p. 260.

70. **Lathyrus palustris**, L., var. **pilosus**, Ledeb. Fl. Ross. I, p. 686; Max. Prim. Fl. Amur. p. 83; F. Schm. Fl. Sach. p. 124; Max. Mél. Biol. IX, p. 61.

Hab. In swampy places; *Etorofu*, at Rubetsu and Shibetoro.

The present variety of this variable and widely distributed species ranges throughout the northeastern part of Asia and adjacent islands, and also in Alaska (Kellogg, U. S. Coast Survey, 1867). It is very common throughout the island of Yezo; but so far, no definite localities have been given for it in the main island of Japan. The plant is be-

lieved by the inhabitants of Etorofu to have great virtues in hysteria, and is largely brought back by the Japanese sailors and fishermen who visit this island. It is known there by the name of *Benizarasa*.

ROSACEÆ.

71. **Prunus Ceraseidos**, Max. Mél. Biol. XI, p. 698. *Ceraseidos apetala*, Sieb. & Zucc. Münch. Abhandl. III, p. 743, t. v, fig. I. 1-8. *Prunus apetala*, Fr. & Sav. Enum. II, p. 329.

Var. **kurilensis**. A straggling shrub; the bark of the young branches greyish or greyish-brown and glabrous; leaves appressed-hairy above, and more or less villose along the veins beneath, orbicular or roundish-oblong, or sometimes obovate at the end of the branches, rounded or obtuse at the base, abruptly cuspidate at the apex, 7–12 (9)–veined, prominently incised-serrate; teeth spreading, 1–3-serrate, and glandular at the tips; pedicels villose; drupe purplish-red (nearly ripened); putamen oval, smoothish, with three nearly parallel veins near its keeled edge. The petiole measures 10–15 mm. long; the blade, 70 × 52 – 85 × 60 mm.; the cuspidate tip, 8–12 mm.; the peduncle, 22 mm. long, and the putamen, 8 × 5 mm.

Hab. In exposed hill tops along the coast; *Etorofu*, at Rubetsu and Shibetoro.

All that I have seen in the above mentioned localities are straggling shrubs about three or four feet high. They may grow larger in less exposed places.

The plant is most closely related to *Prunus Ceraseidos*, Max. The shape and character of the putamen, in these two plants, agree very well. The only prominent points of difference between them are in the form and texture of the leaves. In *Prunus Ceraseidos*, they are broadly elliptical or obovate, and long-cuspidate, and their texture is less coriaceous than that of the Kurile plants. Such differences, however, may be accounted for by the difference in their localities. In the absence of flowers (which are well characterized in *Prunus Ceraseidos* by the great development of the calyx-tube), it is difficult to form any decided opinion as to whether the Kurile plants should be separated from that species or not. So far as my materials allow me to judge, I am inclined to regard it provisionally as a variety of *Prunus Ceraseidos*.

Prunus Ceraseidos has been collected, thus far, only in the alpine and subalpine woods of middle Japan.

72. **Prunus Maximowiczii**, Rupr. in Bull. Acad. St. Petersb. XV, p. 131; Max. Prim. Fl. Amur. p. 89; F. Schm. Fl. Sach. p. 125; Fr. & Sav. Enum. I, p. 118; Max. Mél. Biol. XI, p. 700.

Hab. *Etorofu*, in deciduous woods in the vicinity of Furubetsu and Arimoi.

The plant is found throughout the entire length of Japan; also in Corea, eastern Manchuria and Saghalin.

73. **Prunus Ssiori**, F. Schm. Fl. Sach. p. 124; Max. Mél. Biol. XI, p. 707; Fr. & Sav. Enum. I, p. 119, II, p. 330; Forbes & Hemsley, Index Fl. Sin. p. 221.

Hab. *Etorofu*, in deciduous woods in the vicinity of Furubetsu.

Distrib. Southern Saghalin, northern and middle Japan, northeastern and central China.

74. **?Prunus sp.**, Ledeb. Fl. Ross. II, p. 9.

Hab. *Urup* and *Etorofu* (Pallas).

In his "Neue nordische Beiträge," IV, pp. 131, 133, Pallas mentions a tree from the southern Kuriles, which has the appearance of a birch with birch-like leaves, but with the flowers of *Prunus Padus* (Traubenkirschen), and having hard wood. From this simple description, though graphic, it is rather hard to conjecture what species of *Prunus* or other plant is here meant. To me it seems to apply very well to *Prunus Ssiori*, which I have found in Etorofu. The latter plant has flowers very much like those of *P. Padus*. Its bark looks like that of a birch, and can be peeled off like that in large pieces. Its wood, which is very hard and tough, is used in Yezo for oars, sledges and similar purposes. But its leaves can hardly be called birch-like.

Professor Maximowicz takes the plant referred to by Pallas to be *Sorbus alnifolia*, C. Koch (Mél. Biol. IX, p. 659, in a foot-note, and also in his letter). As its name suggests, the venation of the leaves of *S. alnifolia* is very much like that of *Alnus*. Its wood is very strong and hard, but its inflorescence is different from that of *P. Padus*. *S. alnifolia* has been found in Manchuria and also in the subalpine woods of middle Japan, extending northward to Yezo, where I have collected it even as far north as at Abashiri on the Ochotsk coast. Though no one has ever yet seen or collected *S. alnifolia* in the Kurile islands, it is not at all improbable, judging from its range of distribution, that it does occur there.

75. **Aruncus sylvester**, Kostel.; Max. Act. Hort. Petrop. VI, p. 169. *Spiræa Aruncus*, L.; Ledeb. Fl. Ross. II, p. 16.—Var. **kamtschatica**, Max. *l. c.* p. 170.

Hab. *Kurile islands* (*fide* Max.).

I have adopted in this and the following species the nomenclature set forth by Professor Maximowicz in his revision of the *Spiræaæ*. According to him, this variety has a limited range of distribution in extreme Eastern Siberia, Kamtschatka and the northern Kuriles. The species has a very wide range of distribution in the temperate and subarctic regions of Europe, Asia and North America.

76. **Spiraea betulifolia**, Pall. Fl. Ross. I, p. 33, t. 16; Ledeb. Fl. Ross. II, p. 14; Torr. & Gray, Fl. N. Am. I, p. 414; Max. Act. Hort. Petrop. VI, p. 207.

Hab. *Shikotan.*

My Kurile plant belongs to var. *typica*, fl. *ochroleuco*, Max., which has been found in British Columbia and Alaska, and also in Eastern Siberia, Kamtschatka, Manchuria, Saghalin and northern Japan. In North America the species is more widely distributed, occurring in two or more well definable forms. As var. *corymbosa*, it is found from the Atlantic to the Pacific coasts. As var. *typica*, fl. *roseo*, it occurs in the Pacific regions of North America, in the Rocky Mts. and Sierra Nevada. The same form has been also found in the southeastern part of Manchuria.

77. **Sorbaria sorbifolia**, A. Br. in Aschers. Fl. Brandenb. p. 177; Max. in Act. Hort. Petrop. VI, p. 223. *Spiræa sorbifolia*, L.; Ledeb. Fl. Ross. II, p. 15; F. Schm. Fl. Sach. p. 126.—Var. **stellipila**, Max., *l. c.*

Hab. *Shikotan.*

Distrib. Throughout the island of Yezo from Hakodate to the Ochotsk coast; the island of Saghalin; the eastern and southern portions of Manchuria and in Eastern Siberia. The plant has not yet been found in the main island of Japan.

On the continent, a variety having glabrous leaves is more common and more widely distributed throughout the entire extent of Siberia from the Ural regions to Kamtschatka; and also in Dahuria, Manchuria and Saghalin.

78. **Filipendula kamtschatica**, Max. in Act. Hort. Petrop. VI, p. 248. *Spiræa kamtschatica*, Pall. Fl. Ross. I, p. 41, t. 28; Ledeb. Fl. Ross. II, p. 19; Max. Prim. Fl. Amur. p. 93; F. Schm. Fl. Sach. p. 126.

Hab. Kurile Islands! (herb. Fischer). *Shikotan. Etorofu*, at Furubetsu.

Distrib. In Japan, it is very common in the northern provinces, attaining an enormous size, especially in swampy places in the woods. It is also found in Saghalin and eastern Manchuria, and in Kamtschatka to the Aleutian Islands.

79. **Filipendula palmata**, Max. in Act. Hort. Petrop. VI, p. 250. *Spiræa palmata*, Pall. Reise III, App. p. 735, t. 2, f. 1, and Fl. Ross. I, p. 40, t. 27; Forbes & Hemsley, Index Fl. Sin. p. 226. *Spiræa digitata*, Willd. Spec. II, p. 1061; Ledeb. Fl. Ross. II, p. 17.

Hab. Kuriles ! (*ex* Max.).

Distrib. From Kamtschatka, throughout Eastern Siberia to Dahuria and southeastern part of Mongolia; also in Manchuria, Corea and northern China. It has also been found in Saghalin.

80. **Rubus Chamaemorus**, L.; Ledeb. Fl. Ross. II, p. 71; Torr. & Gray, Fl. N. Am. I, p. 451; Gray, Bot. Jap. p. 187; F. Schm. Fl. Sach. p. 128; Max. Mél. Biol. VIII, p. 374.

Hab. Kuriles, northern (*ex* Pallas).

Distrib. In Japan the plant has been found only in the island of Yezo, where it was collected by J. Small at Cape Romanzoff ($45\frac{1}{2}^{\circ}$ N. lat.), by Dr. Albrecht at Hakodate, and by the writer in a sphagnous bog near Sapporo. The plant is very widely distributed throughout the arctic and subarctic regions of the northern hemisphere. It is noteworthy that this arctic plant descends further southward in the islands of Japan (41°) than in any other portion of the north temperate zone. Next comes the Atlantic coast of North America, where it descends as far south as 44°; in Europe, to 50° in alpine districts; in northwest America to 52°.

81. **Rubus Idaeus**, L., var. **strigosus**, Max. Mél. Biol. VIII, p. 394; Focke in Naturw. Ver. zu Brem. IV, pp. 147 and 156. *Rubus strigosus*, Michx. Fl. Bor.-Am. I, p. 297; Torr. & Gray, Fl. N. Am. I, p. 453. *Rubus Idæus*, Max. Prim. Fl. Amur. p. 99. *Rubus Idæus*, var. *microphyllus*, Turcz. Fl. Baic.-Dah. I, p. 370. *Rubus Idæus*, var. *aculeatissimus*, C. A. Mey. in Reg. & Til. Fl. Ajan. p. 87; F. Schm. Fl. Sach. p. 128.

Hab. Shikotan, on hillsides.

Distrib. Very common throughout the island of Yezo and also in the northern provinces of the main island of Japan. It occurs also in Saghalin, Manchuria and Siberia, from the Altai region to Kamtschatka. The plant is, however, most widely distributed in the subarctic and temperate regions of North America.

Georgi, in his "Geographisch-physikalische und naturhistorische Beschreibung des Russischen Reichs," III, 4, p. 1029, mentions the occurrence of *Rubus fruticosus*, L., in the Kurile Islands. It is most probable that he mistook some other black-berried species for the plant, for we know that *Rubus fruticosus* has thus far been found in a wild state only in Europe and in western Asia as far east as the western temperate Himalaya.

Growing in Yezo and in the alpine districts of the main island of Japan there is a species of *Rubus* with a fruit which is dark-purple when ripe. In its general characters it approaches very closely *Rubus occidentalis* of North America. It forms a shrubby bush, with somewhat recurved stems, which are generally destitute of prickles and glaucous. Young branches and petioles are villosely tomentose, armed with more or less recurved prickles, and often covered with glandular hairs, which are especially prominent on peduncles and pedicels. The leaves are pinnately 3-foliolate; the leaflets broadly ovate, coarsely doubly-serrate, canescently tomentose beneath, the terminal sometimes subcordate at base, and the lateral distinctly short-petioled. The midribs are armed beneath with a few recurved prickles, and the stipules are setaceous. Axillary peduncles 1–3-flowered, the terminal generally 8–10-flowered in a close rounded corymb; pedicels once to twice the length of the calyx lobes, and both calyx and pedicel destitute of prickles. The fruit is roundish, glaucous, and dark-purple when ripe. A partly ripened fruit when dried hardens up close to the stones, showing the lacunose markings on the surface.

From the typical form of *Rubus occidentalis* it is distinguished chiefly by its younger branches being villosely tomentose intermixed often with glandular hairs, and by its pedicels being destitute of prickles. The fruits are somewhat smaller and much more closely clustered. In other respects there are striking resemblances between these two plants.

From *Rubus Idæus*, var. *strigosus* it is easily distinguished by the petioled lateral leaflets, by the absence of prickles on the calyx, by the shape of the inflorescence, and above all by the color of the ripened fruits.

This plant has generally been taken in Japan to be a variety of *Rubus Idæus*, doubtless from the fact that its ripened fruits were not known to collectors. From the descriptions given by Franchet & Savatier of their *R. Idæus*, var. *exsicca*, there is no doubt that their plant is the same as ours. Our plant, however, is very closely related to *R. occidentalis* and should not be placed under *R. Idæus*. As the former is a variable plant and is very widely dispersed through the continent of North America,[1] I prefer to consider our plant as its variety rather than as a distinct new species:—

82. **Rubus occidentalis** var. **japonicus**, L. Sp. p. 493; Torr. & Gray, Fl. N. Am. I, p. 453. *R. Idæus*, var. *exsicca*, Fr. & Sav. Enum. II, p. 334; Matsumura, Cat. Pl. Herb. Imp. Univ. Tokyo, p. 57.

Hab. In the alpine woods of middle *Japan:* Komagatake, Prov. Shinano (Yatabe); Nikko (Savatier); "Niphon media" (Tschonoski!); *Yezo:* in rich alluvial woods, Sapporo (K. M., July, 1880, fl.); in cleared forests, Samani Sando, Prov. Hidaka (K. M., Aug. 19, 1884, fr.); *Kurile Islands?* (Georgi).

83. **Geum strictum**, Ait. Hort. Kew. II, p. 217; Ledeb. Fl. Ross. II, p. 22; Torr. & Gray,

[1] Focke, Batographische Abhand. in Naturw. Verein zu Bremen IV, pp. 117 and 165.

Fl. N. Am. I, p. 421; F. Schm. Fl. Sach. p.126; Fr. & Sav. Enum. I, p. 128, II, p. 335; Schentz, Prod. Monog. Georum, p. 28.

Hab. *Etorofu*, in the vicinity of Furubetsu.

Distrib. Eastern Europe, northern Asia, northern and middle China, Corea, Japan, North America, South America and New Zealand.

84. **Geum macrophyllum**, Willd. Enum. I, p. 557; Torr. & Gray, Fl. N. Am. I, p. 421; Ledeb. Fl. Ross. II, p. 23; F. Schm. Fl. Sach. p. 126. *G. japonicum*, Schentz, Monog. p. 31 (not Thunb., and excl. Jap. plants).

Hab. *Kurile Islands* (*ex* F. Schmidt).

There is great confusion in this group of *Geum*, evidently caused by a striking similarity in the character of the akenes and by a variability in the shape of the leaves and in the pubescence. For instance a gradual transition is found between *G. macrophyllum* and *strictum*. F. Schmidt denies even the value of the hairs on the receptacle as a reliable distinguishing character among the Asiatic plants.

Examination of a large number of the American specimens of these species in the Gray Herbarium indicates that the receptacle of *G. macrophyllum* is always subglabrous, or at least very much less hairy than in the case of *G. strictum*. In *G. macrophyllum*, the large and round-heart-shaped terminal leaflets of the radical leaves and also the bristly hairiness of the stem and petiole are quite constant; while in *G. strictum* these characters are exceedingly variable.

N. J. Schentz in his monograph of the genus *Geum* brings together *G. japonicum*, Thunb., and *G. macrophyllum*, Willd., as one and the same species. But there are many important points of difference between these two plants, which seem to prove very distinctly that they are as distinct from each other as any two related species in this genus. *G. japonicum* has softer and denser pubescence, and is generally more or less bent in a zigzag way; its upper cauline leaves are rounded and petioled and dentate, and not coarsely serrate or doubly-serrate as in *G. macrophyllum*. The most important distinguishing character is that the receptacle in the former is even more hairy than in *G. strictum*, though Schentz describes it as glabrous or obscurely pubescent.

Distrib. Widely spread in North America from the Atlantic to the Pacific coasts; Aleutian Islands; Kamtschatka and Kurile Islands.

85. **Potentilla fruticosa**, L., Sp. p. 495; Georgi, Besch. III, p. 1033; Ledeb. Fl. Ross. II, p. 61; Torr. & Gray, Fl. N. Am. I, p. 445; Lehm. Rev. Pot. p. 16; Max. Mél. Biol. IX, p. 157; Fr. & Sav. Enum. I, p. 133.

Hab. *Kurile Islands* (*ex* Georgi). *Shikotan*, on hillsides and grassy places on the beach.

Distrib. Northern and western Europe, northern Asia, Himalaya, northern China, northern and middle Japan, Saghalin and North America.

The inhabitants of the northern Kuriles are said to drink a decoction of its leaves as a tea.

86. **Potentilla fragarioides**, L., var. **stolonifera**, Max. Mél. Biol. IX, p. 160; Hook. f., Fl. Brit. Ind. II, p. 351. *P. stolonifera*, Lehm. in Ind. Sem. H. Bot. Hambg., 1831, n. 5, and Revis. Pot. p. 11, t. 15; Ledeb. Fl. Ross. II, p. 38. *P. fragarioides*, Schlecht. & Cham. in Linnaea, II, p. 25.

Hab. *Shikotan*, in grassy places on the beach. *Etorofu*, at Furubetsu.

My Kurile specimens correspond very well with the figure and description of Lehmann in his Revisio Potentillarum. Some of the radical leaves of the plant collected at Furubetsu attain the enormous length of 30 cm. These leaves have in all cases only two pairs of lateral leaflets; while the smaller leaves have generally three pairs, the pairs decreasing in size toward the base. The akenes are glabrous, and sometimes more or less wrinkled; the styles subterminal, and slightly shorter than the akenes; and the receptacle very hairy.

P. fragiformis var. *japonica*, A. Gray, Bot. Jap. p. 387, which Professor Maximowicz makes a synonym of our present plant, proves according to the original specimen to be *P. fragarioides*, var. *ternata*.

Distrib. Kamtschatka and adjacent islands, Saghalin, Japan, and eastern Himalaya (*ex* Max.).

87. **Potentilla fragiformis**, Willd. in Magaz. d. Gesellsch. naturf. Freunde zu Berl. VII, p. 294; Ledeb. Fl. Ross. II, p. 59; Ser. in DC. Prodr. II, p. 586; Lehm. Monog. Pot. p. 163, t. 15, and Rev. Pot. p. 155; Reg. & Til. Fl. Ajan. p. 85; Max. Prim. Fl. Amur. p. 96; F. Schm. Fl. Sach. p. 127; Watson in Proc. Am. Acad. VIII, p. 559; Forbes & Hemsley, Index Fl. Sin. p. 242. *P. grandiflora*, L., var. *fragiformis*, Ser. in DC. Prodr. p. 572. *P. grandiflora*, Max. Mél. Biol. IX, p. 161.

Hab. *Kurile Islands!* (*ex* Max.). *Etorofu*, on rocky cliffs near Rubetsu.

Densely villose; stem ascending, 20–30 cm. long; radical leaves moderately villose (in small older leaves), or densely silky villose (in younger larger leaves); leaflets rhombic cuneate; teeth deeply cut, oblong and obtuse; cyme generally about 5-flowered; bractlets broadly ovate and obtuse, shorter than the lanceolate or ovate-lanceolate sub-acute sepals; sepals and bractlets erect in fruit, enclosing many smooth akenes which are more or less distinctly keeled.

The plants collected at Kombumori and Nemuro on the northeastern coast of Yezo were equally large and were in flower. The flowers are very large, measuring about 40 mm. across.

Distrib. Siberia from the Altai region to Kamtschatka; Manchuria, northeastern and middle China, Saghalin, Yezo, Aleutian Islands, Alaska to Washington Territory.

Professor Maximowicz considers the European *P. grandiflora*, L., and *P. fragiformis*, Willd., of northeastern Asia, as identical, on the ground that the distinctive characters based on the bractlets and the teeth of the leaves do not hold very well in every case. He includes under the same species *P. gelida*, C. A. Mey., and also *P. villosa*, Pall., as its varieties. A similar opinion is endorsed by Sir J. D. Hooker in his Flora of British India, II, p. 357, in connection with *P. gelida*.

So far as the materials at my hand allow me to judge, there seems to be a well marked distinctive character in the ripened akenes of these plants, which if proved to be constant in all other cases would help not a little in determining their relative position.

Potentilla grandiflora:—Akenes ovoid, glabrous, obtusely and obscurely ridged on the margin, with four prominent curved veins running almost parallel ("arcuato-rugosis" of Seringe).

P. fragiformis:—Akenes elongated-ovoid, larger (1.8 mm. long), smooth, with a more or less prominently keeled ridge on the margin, the veins inconspicuous.

P. villosa:—Akenes elongated-ovoid, smooth, with the margin more or less prominently ridged, the veins inconspicuous.

P. gelida:—Akenes ovoid, glabrous, with 3–4 distinct curved veins running almost parallel, obtusely ridged.

It will be seen from the characters of the ripened akenes, that *P. grandiflora* and *gelida* are closely related; while *P. fragiformis* and *villosa* form another group.

88. **Potentilla anserina** L. Sp. p. 495; Ledeb. Fl. Ross. II, p. 44; Lehm. Rev. Pot. p. 188; Watson, Proc. Am. Acad. VIII, p. 562; Fr. & Sav. Enum. I, p. 131.

Hab. *Etorofu*, at Rausu.

Distrib. Arctic and temperate regions of Europe, Asia and North America. Also in South America and Australia.

89. **Agrimonia Eupatoria**, L. Sp. p. 448; Ledeb. Fl. Ross. II, p. 31; Torr. & Gray, Fl. N. Am. I, p. 431; Forbes & Hemsley, Ind. Fl. Sin. p. 246. *A. pilosa*, Ledeb. Ind. Sem. H. Dorp. Suppl., 1823, p. 1. *A. viscidula*, Bunge, Enum. Pl. Chin. Bor. p. 26.

Hab. *Shikotan.*

Distrib. Throughout the temperate regions of the northern hemisphere.

90. **Sanguisorba tenuifolia**, Fisch. *ex* Link., Enum. Pl. Hort. Berol. I, p. 144; Ledeb. Fl. Ross. II, p. 28; Max. Mél. Biol. IX, p. 152.—Var. **alba**, Trautv. & Mey. Fl. Ochot. p. 35; Max., *l. c.*, p. 153. *Poterium tenuifolium*, var. *album*, Fr. & Sav. II, p. 342; Forbes & Hemsley, Ind. Fl. Sin. p. 247.

Hab. *Shikotan.* *Etorofu*, at Rubetsu.

Distrib. Eastern Siberia, Kamtschatka, Manchuria, Dahuria, China, Corea, northern and middle Japan and Saghalin.

91. **Rosa acicularis**, Lindl. Ros. Monog. p. 44, t. 8; C. A. Meyer, Zimmtrosen, p. 15; Crepin, Prim. Monog. Ros. p. 299; Regel, Tent. Ros. Monog. p. 18.

Hab. *Etorofu*, in roadside thickets at Tsurubetsu.

Distrib. Europe, northern Asia, China, northern and middle Japan, and in North America.

92. **Rosa rugosa**, Thunb. Fl. Jap. p. 213; C. A. Mey., Zimmtrosen, p. 32; Crepin, Prim. Monog. Ros. p. 336; Regel. Tent. Ros. p. 24; Sieb. & Zucc. Fl. Jap. I, p. 66, t. 28. *R. kamtschatica*, Red. Ros. I, p. 47.

Hab. On the sandy beach: *Shikotan.* *Etorofu*, at Tsurubetsu, Shana and Shibetoro, *Shimushu* (S. Akakabe). *Kuriles* (*ex* Georgi, Pallas).

Distrib. Japan, Saghalin, Kamtschatka, Manchuria, Corea and China.

93. **Pyrus sambucifolia**, Cham. & Schlecht. in Linnæa, II, p. 36; Torr. & Gray, Fl. N. Am. I, p. 472; Ledeb. Fl. Ross. II, p. 99; Max. Prim. Fl. Amur. p. 103, and Mél. Biol. IX, p. 172 (under *Sorbus*).

Hab. *Kurile Islands* (*ex* Pallas). *Etorofu*, very common on hillsides, forming stunted

shrubs, a foot to three feet in height in exposed places, as at Rubetsu and Shibetoro, or attaining a height of eight to ten feet in sheltered places, as at Furubetsu and Arimoi.

Distrib. Manchuria, Eastern Siberia along the Ochotsk Sea to Kamtschatka, Saghalin, middle and northern Japan, islands in the Behring Sea, Alaska to the Sierra Nevada and Rocky Mountains (to Colorado), and eastward through British America to Labrador and northern New England.

SAXIFRAGACEÆ.

94. Astilbe Thunbergii, Miq. Prol. Fl. Jap. p. 260; Fr. & Sav. Enum. I, p. 143; Forbes & Hemsley, Index Fl. Sin. p. 266. *Hoteia Thunbergii*, Sieb. & Zucc. Fl. Jap. Fam. Nat. II, p. 367.

Hab. *Etorofu*, at Furubetsu.

Distrib. Japan and central China.

95. Saxifraga fusca, Max. Mél. Biol. VIII, p. 602; Fr. & Sav. Enum. I, p. 146, II, p. 354.

Hab. *Etorofu*, along a shady stream near Tsurubetsu.

Distrib. Common in the island of Yezo, and rarely in the subalpine regions of middle Japan.

The plant is closely related to *Saxifraga punctata*, L., which grows in the subalpine regions of northeastern Asia, extending to Alaska and the Rocky Mountains.

96. Saxifraga reflexa, Hook. Fl. Bor.-Am. I, p. 249, t. 85; Engl. Monog. Saxif. p. 143; A. Gray, Proc. Am. Acad. XX, p. 11. *S. Tilingiana*, Regel in Regel & Til. Fl. Ajan. p. 94; Engl. Monog. p. 142. *S. Sachalinensis*, F. Schm. Fl. Sach. p. 133. *S. Virginiensis*, var. *yezoensis*, Franchet in Bull. de la Soc. Philom. de Paris, avril, 1888.

Hab. *Shikotan*, on rocky cliffs.

I have followed Dr. Gray in referring our plant as well as *S. Tilingiana* to Hooker's *S. reflexa*, which he distinguishes from *S. virginiensis* by the following characters: — "calyx reflexed in or after anthesis, almost free; pedicels all slender and longer than calyx; filaments disposed to be upwardly dilated, sometimes conspicuously so,"— *l. c.*, p. 10. There is a great variation in the nature and amount of the pubescence, and in the shape of the leaves, with all gradations between the extremes.

Distrib. Common in the middle and northern parts of Yezo, in southern Kuriles and Saghalin; also in Eastern Siberia about Ajan; and in North America, from Arctic Alaska southward along the northern Rocky Mountains, thence along the Cascades and the Sierra Nevada to southern California.

97. Saxifraga Merkii, Fisch. in Sternb. Rev. Sax. Suppl. I, p. 1, t. 1, f. 3, II, p. 19; Ser. in DC. Prodr. IV, p. 24; Engl. Monog. Sax. p. 208.

Hab. Second Island (*Paramushir*)! (*ex* Max.).

Distrib. About the Baikal Lake, Ajan (Small!), Kamtschatka and the Kurile Islands; as var. *Idsuœi*, Engl., in the alpine district of middle Japan.

98. Saxifraga bronchialis, L. Sp. p. 400; Ledeb. Fl. Ross. II, p. 207; Hook. Fl. Bor.-Am. I, p. 254; Engl. Monog. Sax. p. 215.

Hab. *Shikotan*, on rocky cliffs.

Distrib. Arctic Russia in Europe, and throughout northern Asia to Alaska, and on the Sierra Nevada and Cascade Range, and the Rocky Mountains as far south as New Mexico.

99. **Chrysosplenium kamtschaticum**, Fisch. in DC. Prodr. IV, p. 48; Ledeb. Fl. Ross. II, p. 227; F. Schm. Fl. Sach. p. 134; Max. Mél. Biol. IX, p. 765. *C. oppositifolium*, Cham. in Linnæa, VI, p. 557.

Hab. *Urup!* (*ex* Max.).

Distrib. Extreme Eastern Siberia, Kamtschatka, the Kuriles and Saghalin.

100. **Parnassia palustris**, L. Sp. p. 273; Ledeb. Fl. Ross. I, p. 262; Torr. & Gray, Fl. N. Am. I, p. 148; Miq. Prol. Fl. Jap. p. 261.

Hab. *Urup!* (*ex* Max.). *Etorofu*, in the vicinity of Rubetsu.

Distrib. In the subalpine and subarctic regions of the northern hemisphere.

101. **Hydrangea scandens**, Max. Rev. Hydr. As. Or. p. 16; F. Schm. Fl. Sach. p. 130. *H. cordifolia*, *petiolaris* and *bracteata*, Sieb. & Zucc. Fl. Jap. p. 113, t. 59, f. II, p. 106, t. 54, p. 176, t. 92. *H. petiolaris*, Fr. & Sav. Enum. I, p. 153.

Hab. *Etorofu*, in deciduous woods near Furubetsu.

This polymorphous species is strictly insular, so far as we are informed, dispersed from the subalpine regions of Kinsiu to the southern part of Saghalin and the Kuriles. Several varieties have been proposed by different authors, but in nature there is such a gradual transition between them as to make their use almost impossible.

102. **Ribes triste**, Pall. in Nov. Act. Petrop. X, p. 378; Ledeb. Fl. Ross. II, p. 198; Max. Mél. Biol. IX, p. 235. *R. melancholium*, Sievers *ex* Pallas *l. c.* *R. propinquum*, Turcz. in Bull. Mosc. (1840) p. 70; Max. Prim. Fl. Amur. p. 119. *Ribes rubrum*, var. *propinquum*, Trautv. & Mey. Fl. Ochot. p. 40; Reg. & Til. Fl. Ajan. p. 93.

Hab. *Kurile Islands!* (*ex* Turcz., Max.).

Distrib. Eastern Siberia about the Ochotsk Sea to arctic Siberia and to the Baikal region; also in northern Manchuria, and in the Kurile Islands.

CRASSULACEÆ.

103. **Sedum Rhodiola**, DC. Prodr. III, p. 401; Ledeb. Fl. Ross. II, p. 179; Reg. & Til. Fl. Ajan. p. 89; A. Gray, Manual, p. 172; Max. Mél. Biol. XI, p. 734.

Hab. *Kurile Islands* (*ex* Reg. & Tiling). *Urup!* (Wrangell). *Shikotan*, on rocky cliffs along the harbor. *Etorofu*, at Tsurubetsu.

This polymorphous species is widely distributed in the arctic and alpine regions of Europe, Asia and North America; especially common on marine cliffs in high latitudes.

104. **Sedum kamtschaticum**, Fisch. in Ind. Sem. Hort. Petrop. VII, p. 54; Ledeb. Fl. Ross. II, p. 182; F. Schm. Fl. Sach. p. 132; Max. Mél. Biol. XI, p. 759. *Sedum hybridum*, A. Gray, Bot. Jap. p. 427.

Hab. *Shikotan*, on rocky cliffs about the harbor.

Distrib. Eastern Siberia, Kamtschatka, Manchuria, Saghalin, Japan, Corea and China.

ONAGRARIEÆ.

105. **Epilobium Behringianum**, Hausskn. Monog. Epilob. p. 277. *E. origanifolium*, Cham. & Schlecht. in Linnæa, II, p. 553.

Hab. Kuriles; Urup (hb. Petrop. *ex* Hausskn.).

Distrib. Sitka through the Aleutian Islands to Kamtschatka and the Kurile Islands.

106. **Epilobium Bongardi**, Hausskn. Monogr. Epilob. p. 278. *E. roseum*, Bong. Veg. Sitcha in Mém. Ac. Petrop. (1833) VI, p. 135; Torr. & Gray, Fl. N. Am. I, p. 489; Ledeb. Fl. Ross. II, p. 111 (in part). *E. Hornemanni*, Bong. *l. c.* p. 136; Ledeb. *l. c.* p. 112 (in part).

Hab. Urup (hb. Petrop., *ex* Hausskn.).

Distrib. Insular,—Sitka, through the Aleutian Islands to Kamtschatka and the Kurile Islands.

107. **Epilobium latifolium**, L. Sp. p. 347; Ledeb. Fl. Ross. II, p. 106; Torr. & Gray, Fl. N. Am. I, p. 487; Trautv. & Mey. Fl. Och. p. 38; Clarke in Hook. Fl. Brit. Ind. II, p. 583.—Var. **kamtschatica**, Hausskn. *l. c.* p. 191. *E. Kamtschaticum*, Led. in Nova Act. Petrop. XI, p. 370, t. 6.

Hab. Kuriles (Vahl. in hb. Willd.). *Urup!* (*ex* Max., Hausskn.).

Distrib. The species is widely distributed in the arctic and northern temperate regions of Asia, North America, and the extreme north of Europe; and in the alpine districts of West Himalaya, and of western North America to Colorado and California.

108. **Epilobium lactiflorum**, Hausskn. Monog. p. 158.

Hab. Kurile Islands (hb. Fisch. *ex* Hausskn.).

Distrib. Scandinavia, Iceland, Greenland, Labrador to Sitka, extending south into the Lake region and the White and Rocky mountains; Kamtschatka and the Kuriles.

109. **Epilobium angustifolium**, L. Sp. p. 347; Ledeb. Fl. Ross. II, p. 105; Torr. & Gray, Fl. N. Am. I, p. 487; Trautv. & Mey. Fl. Och. p. 37; Reg. & Til. Fl. Ajan. p. 88; F. Schm. Fl. Sach. p. 129; Hausskn. Monog. p. 37. *E. spicatum*, Lam. Fl. Fr. p. 1077; Fr. & Sav. Enum. I, p. 168.

Hab. Etorofu, at Furubetsu and Shibetoro. *Urup* (leg. Mertens, *ex* Hausskn.).

Distrib. Widely spread in the arctic and temperate regions of Europe, Asia and North America.

110. **Circaea alpina**, L. Sp. p. 9; Ledeb. Fl. Ross. II, p. 114; Hook. Fl. Bor.-Am. I, p. 215; A. Gray, Bot. Jap. p. 389; F. Schm. Fl. Sach. p. 129; Fr. & Sav. Enum. I, p. 170.

Hab. Shikotan. Etorofu, at Furubetsu.

Distrib. Europe, northern Africa, and in the cool temperate and alpine regions of Asia and North America.

UMBELLIFERÆ.

111. **Aegopodium alpestre**, Ledeb. Fl. Alt. I, p. 354, Fl. Ross. II, p. 248; Trautv. & Mey. Fl. Ochot. p. 43; Reg. & Til. Fl. Ajan. p. 96; Max. Prim. Fl. Amur. p. 124; F. Schm. Fl. Sach. p. 135.

Hab. *Shikotan*, in grassy places, on top of cliffs.

Distrib. From the Altai and Baikal regions of Siberia to the Ochotsk district, and northern Manchuria; Saghalin, and Yezo (Sapporo, Prov. Ishikari; Sarnru Sando, Prov. Hidaka; Otsnishi, Prov. Nemuro).

112. **Anthriscus sylvestris**, Hoffm. Umbel. pp. 40, 46, t. 1, f. 19; Ledeb. Fl. Ross. p. 346; A. Gray, Bot. Jap. p. 390; Fr. & Sav. Enum. 1, p. 183. *Chærophyllum sylvestre*, L.; Georgi, Beschr. d. Russ. R. III, 4, p. 855. *Anthriscus nemorosa*, F. Schm. Fl. Sach. p. 140.

Hab. *Kurile Islands* (Steller *ex* Georgi). *Etorofu*, at Furnbetsu, and Shana.

Distrib. Europe, northern Africa, northern Asia, northeastern China and Japan.

113. **Ligusticum scoticum**, L. Sp. p. 250; Ledeb. Fl. Ross. II, p. 286; Max. Mél. Biol. IX, p. 249; Coulter & Rose, Rev. N. Am. Umb. p. 85. *Haloscias scoticum*, Fries Summa Veget. Scand. 1, p. 180; Max. Fl. Amur. p. 126; F. Schm. Fl. Sach. p. 135.

Hab. *Etorofu*, at Tsurnbetsu.

Distrib. The coast regions of the arctic and north temperate regions of Europe, Asia and North America.

114. **Pleurospermum austriacum**, Hoffm. Umb. p. VIII; DC. Prodr. IV, p. 244; Ledeb. Fl. Ross. II, p. 360; Turcz. Fl. Baic.-Dah. 1, p. 512; Max. Prim. Fl. Amur. p. 130; Forbes & Hemsley, Index Fl. Sin. p. 333. *P. kamtschaticum*, Hoffm. Umbel. p. X; Ledeb. Fl. Ross. II, p. 361; F. Schm. Fl. Sach. p. 140; Fr. & Sav. Enum. 1, p. 186. *P. uralense*, Hoffm. *l. c.*

Hab. *Etorofu*, at Rubetsu.

Distrib. Central and eastern Europe, across southern Siberia to Manchuria and northeastern China, Saghalin, northern and middle Japan and Kamtschatka.

115. **Angelica anomala**, Lallem. in Ind. Sem. Hort. Petrop. IX, p. 57; Regel, Tent. Fl. Uss. p. 70; F. Schm. Fl. Sach. p. 137 (excl. syn. *A. japonica*). *A. montana*, var. *angustifolia*, Ledeb. Fl. Ross. II, p. 295. *A. sachalinensis*, Max. Prim. Fl. Amur. p. 127.

Hab. *Etorofu*, in grassy places on the marine terraces near Shana and Shibetoro.

Distrib. From the Baikal region of Siberia to Manchuria and northeastern China; also in southern Saghalin and Yezo: Sempoji, Prov. Kushiro.

116. **Coelopleurum Gmelini**, Ledeb. Fl. Ross. II, p. 361; A. Gray, Pl. Jap. p. 312, Bot. Jap. p. 391; F. Schm. Fl. Sach. p. 136; Coulter & Rose, Rev. N. Am. Umbel. p. 90. *Archangelica Gmelini*, DC. Prodr. IV, p. 170; Hook. Fl. Bor.-Am. 1, p. 267; Fr. & Sav. Enum. 1, p. 188. *Angelica maculata*, Turcz. Bull. Mosc., 1840, p. 72. *Physolophium saxatile*, Trantv. & Mey. Fl. Och. p. 44; F. Schm. in Max. Fl. Amur. p. 126.

Hab. *Kurile Islands* (*ex* Turcz.).

Distrib. Coast regions of Manchuria, Eastern Siberia, Kamtschatka, Saghalin, and northern and middle Japan; Alaska, the Pacific and Atlantic coasts of British America and also New England and Greenland.

117. **Heracleum lanatum**, Michx. Fl. Bor.-Am. 1, p. 166; A. Gray, Bot. Jap. p. 391;

Max. Fl. As. Or. Frag. p. 23; Forbes & Hemsley, Index Fl. Sin. p. 336. *Heracleum dissectum*, Ledeb. Fl. Alt. I, p. 301. *H. barbatum*, Ledeb. Fl. Alt. I, p. 300; F. Schm. in Max. Fl. Amur. p. 129, Fl. Sach. p. 138; Fr. & Sav. Enum. I, p. 189.

Hab. *Kurile Islands* (*ex* Pallas, Georgi). *Etorofu*, at Furubetsu.

Distrib. From the Altai region of Siberia to central and northern China, Manchuria, Japan, Saghalin, Eastern Siberia and Kamtschatka, and widely spread in the subarctic and temperate regions of North America, especially along the high mountains towards the south.

ARALIACEÆ.

118. Aralia racemosa, L. Sp. p. 273; Torr. & Gray, Fl. N. Am. I, p. 646.—Var. **sachalinensis**, Regel, Gartenflora, 1864, p. 100, t. 432, Ind. Sem. Hort. Petrop., 1864, p. 22; F. Schm. Fl. Sach. p. 141. *Aralia cordata*, Thunb. Fl. Jap. p. 127; Fr. & Sav. Enum. I, p. 191. *Aralia edulis*, Sieb. & Zucc. Fl. Jap. I, p. 57, t. 25.

Hab. *Etorofu*, in roadside thickets near Furubetsu.

Distrib. Southern Saghalin and Japan. The plant is very common in the island of Yezo and in the northern provinces of the main island. Toward the south it is chiefly met with in a cultivated state.

Our plant differs from the American one in its leaflets being generally simply serrate, and its young fruits turbinate. Its styles have a less tendency to diverge at first, though they are seen recurved regularly in ripened fruits. The flowers may be a little larger in the Japanese plant, and are said to be sometimes 6-merous. In other characters the two plants can scarcely be distinguished in dried specimens.

In North America the plant grows in rich woodlands on the Atlantic side from Canada to the mountains of Georgia, and it is also found at the base of the Rocky Mountains.

119. Acanthopanax ricinifolium, Seeman in Journ. Bot., 1868, p. 140, and Rev. Heder. p. 86; Forbes & Hemsley, Index Fl. Sin. p. 340. *Panax ricinifolium*, Sieb. & Zucc. Fl. Jap. Fam. Nat. I, p. 91. *Kalopanax ricinifolium*, Miq. in Ann. Mus. Bot. Lugd.-Bat. I, p. 16; F. Schm. Fl. Sach. p. 140. *Brassaiopsis ricinifolia*, Seeman in Journ. Bot., 1864, p. 291.

Hab. *Etorofu*, in sheltered valleys near Furubetsu, and at Arimoi.

Distrib. Southwestern Saghalin, Japan, Corea and China.

CORNACEÆ.

120. Cornus canadensis, L. Sp. p. 117; Torr. & Gray, Fl. N. Am. I, p. 652; Ledeb. Fl. Ross. II, p. 378; A. Gray, Bot. Jap. p. 391.

Hab. *Kurile Islands* (Merk. *ex* Rudolph). *Etorofu*, at Furubetsu, Arimoi and Shibetoro. *Kunashiri* (G. Mori).

Distrib. Subarctic and alpine regions of North America and northeastern Asia, as far south as the eastern side of Corea and middle Japan.

121. Cornus suecica, L. Sp. p. 118; Torr. & Gray, Fl. N. Am. I, p. 653; Ledeb. Fl. Ross. II, p. 377; A. Gray, Bot. Jap. p. 391; Fr. Schm. Fl. Sach. p. 141.

Hab. *Shikotan*, in grassy places on the top of cliffs.

Distrib. Arctic and northern Europe, Asia and North America.

GAMOPETALÆ.

CAPRIFOLIACEÆ.

122. Sambucus racemosa, L. Sp. p. 270; Ledeb. Fl. Ross. II, p. 383; A. Gray, Synop. Fl. I, p. 8; Max. Prim. Fl. Amur. p. 135; Miq. Prol. Fl. Jap. p. 135. *S. pubens*, Michx. Fl. Bor.-Am. I, p. 181. *S. pubescens*, Pers. Syn. I, p. 328. *S. racemosa*, var. *pubens*, Trautv. & Mey. Fl. Och. p. 46.

Hab. *Etorofu*, at Furubetsu.

Distrib. Temperate regions of Europe, northern and eastern Asia, and North America.

123. Viburnum Opulus, L. Sp. p. 268; Ledeb. Fl. Ross. II, p. 384; Max. Prim. Fl. Amur. p. 135, and Mél. Biol. X, p. 670; A. Gray, Synop. Fl. I, p. 10; Fr. & Sav. Enum. I, p. 199.

Hab. *Etorofu*, in the roadside thicket near Shana.

Distrib. Temperate and subarctic regions of Europe; northern Asia, northern China, northern and middle Japan; and in North America, from Alaska to Oregon on the western coast, and New Brunswick to Pennsylvania on the east.

124. Linnaea borealis, Gronov.; Ledeb. Fl. Ross. II, p. 392; A. Gray, Synop. Fl. I, p. 13; Max. Prim. Fl. Amur. p. 139; F. Schm. Fl. Sach. p. 143.

Hab. *Shimushu* (Prof. J. Milne, *ex* James Bisset). *Etorofu*, at Nobori in the region of *Pinus pumila*.

Distrib. Arctic and alpine regions of northern Europe, northern Asia, and North America.

This plant was also collected on Mt. Poroshiri in the central part of Yezo by S. Tanouchi in 1882.

125. Lonicera caerulea, L. Sp. p. 174; Ledeb. Fl. Ross. II, p. 390; A. Gray, Synop. Fl. I, p. 15. *L. cærulea*, var. *villosa*, Torr. & Gray, Fl. N. Am. II, p. 9; Herder, Pl. Radd. III, p. 18, t. 3, f. 3; Max. Mél. Biol. X, p. 75.

Hab. *Etorofu*, at Furubetsu and Shibetoro.

Distrib. Marshy places of the arctic and subalpine regions of Europe, northern Asia, and North America.

A villose form, to which my Kurile specimens belong, is found in northern Japan, Saghalin, Kamtschatka, northeastern Manchuria, Dahuria, and across Siberia to northern Russia; and is also dispersed in British America and in the Sierra Nevada.

126. Lonicera Maximowiczii, Rupr. Pl. Max. n. 33, in Bull. phys. math. Peterb. XV; Max. Prim. Fl. Amur. p. 137, and Mél. Biol. X, p. 60; Herd. Pl. Radd. III, p. 14, t. II, f. 6, and Addenda, p. 18; F. Schm. Fl. Sach. p. 142 (var. *sachalinensis*).

Hab. *Shikotan*, on hillsides. *Etorofu*, at Furubetsu.

Distrib. In the mountain woods of eastern Manchuria, Saghalin and Yezo. In the island of Yezo I have found this plant thus far only in places of a volcanic origin, where

the subsoil is entirely composed of disintegrated lava; as at Chitose, Prov. Iburi, Nakaware, Prov. Nemuro, and Shari, Prov. Kitami.

According to Prof. Maximowicz, it is said to be closely related to *L. conjugialis*, Kellogg, of California.

127. **Lonicera Chamissoi**, Bunge in Kirol. Lonic. d. russ. R. p. 28; Max. Fl. Amur. p. 136; Herd. Pl. Radd. III, p. 19, t. 2, f. 1, 2, and Add. and Emend. p. 25; Max. Mél. Biol. X, p. 60. *Lonicera nigra*, Ledeb. Fl. Ross. II, p. 389 (in part).

Hab. *Kurile Islands!* (herb. Fisch.). *Etorofu*, in grassy places on the top of hills, at Shibetoro.

Distrib. Kamtschatka, Eastern Siberia on the Ochotsk border, northeastern Manchuria, Saghalin and Yezo: Mt. Poroshiri, Prov. Tokachi (S. Tanouchi, 1882).

128. **Diervilla Middendorffiana**, Carr. in Rev. Hort., 1853, p. 306, 1854, p. 261, t. 14; Max. Mél. Biol. XII, p. 482. *Calyptrostigma Middendorffianum*, Trautv. & Mey. in Bull. phys. math. Pétersb. XIII, p. 220, and Fl. Och. p. 46, t. 25, f. a, b; Max. Fl. Amur. p. 135; F. Schm. Fl. Sach. p. 142; Herder, Pl. Radd. III, Add. and Emend. I, p. 12.

Hab. *Kurile Islands!* (Max.).

Distrib. Eastern Siberia about Ochotsk, northeastern Manchuria, Saghalin, northern and middle Japan.

RUBIACEÆ.

129. **Rubia tatarica**, F. Schm. Fl. Sach. p. 143. *Galium tataricum*, Trev.; Ledeb. Fl. Ross. II, p. 410.—Var. **grandis**, F. Schm., *l. c.*; Max. Mél. Biol. IX, p. 266; Herd. Pl. Radd. III, Add. and Emend. II, p. 4. *G. jezoense*, Miq. Prol. p. 276.

Hab. *Shikotan*, in wet grassy places along the beach. *Etorofu*, at Rausu.

Distrib. Yezo, Saghalin and Manchuria.

The typical form is found in the steppes of middle and southern Russia, extending eastward to Songaria.

130. **Galium verum**, L. Sp. p. 107; Ledeb. Fl. Ross. II, p. 414; Herder, Pl. Radd. III, p. 32; Max. Mél. Biol. IX, p. 265; Fr. & Sav. Enum. I, p. 215.

Hab. *Shikotan*, in grassy places along the beach. *Etorofu*, at Tsurubetsu and Shibetoro.

Distrib. Europe, northern Africa, northern and eastern Asia and Himalaya.

131. **Galium kamtschaticum**, Steller in Rœm. & Schult. Syst. III, Mant. p. 186; A. Gray, Proc. Am. Acad. XIX, p. 80, Synop. Fl. I, p. 37. *Galium obovatum*, Ledeb. Fl. Ross. II, p. 412 (not HBK.); Max. Mél. Biol. IX, p. 262.

Hab. *Etorofu*, at Furubetsu.

Distrib. Saghalin, northern and middle Japan in alpine woods; Kamtschatka; the Aleutian Islands to the mountains of Oregon and Washington, and also in those of lower Canada and New England.

132. **Asperula odorata**, L. Sp. p. 103; Ledeb. Fl. Ross. II, p. 400; A. Gray, Bot. Jap. p. 393; Max. Mél. Biol. IX, p. 267; F. Schm. Fl. Sach. p. 144; Fr. & Sav. I, p. 211; Herder, Pl. Radd. III, Add. and Emend. II, p. 5.

Hab. *Etorofu*, in sheltered woods in the vicinity of Furubetsu.

Distrib. Europe; northern Africa to southwestern Siberia and middle Asia; in alpine woods of middle Japan, and northward to Yezo, Saghalin and the southern Kuriles.

COMPOSITÆ.

133. Solidago Virgaurea, L. Sp., p. 880; Ledeb. Fl. Ross. II, p. 493; Max. Prim. Fl. Amur. p. 149; Hook. f. Fl. Brit. Ind. III, p. 245; A. Gray, Synop. Fl. I, p. 148; Fr. & Sav. Enum. I, p. 228.

Hab. *Shikotan*. *Etorofu*, at Furubetsu and Shibetoro.

Distrib. Europe, northern and eastern Asia, Himalaya and North America.

134. Aster Glehni, F. Schm. Fl. Sach. p. 146; Fr. & Sav. Enum. I, p. 223.

Hab. *Shikotan*, on hillsides.

Distrib. In Japan, from Kiusiu to Yezo and the southern Kuriles, and Saghalin.

135. Erigeron salsuginosus, A. Gray, Proc. Am. Acad. XVI, p. 93, Synop. Fl. I, p. 208. *Aster salsuginosus*, Richards. in Franklin Journ. Add. ed. 2, p. 32; Hook. Bot. Mag. t. 4942; Ledeb. Fl. Ross. II, p. 474. *Aster unalaschensis*, Less. *ex* Bong. Veg. Sitch. p. 148. *A. peregrinus*, Herder, Pl. Radd. III, 2, p. 10 (partly). *A. japonicus*, Less. in DC. Prodr. V, p. 228; A. Gray, Pl. Jap. p. 314. *Inula dubia*, Thunb. Fl. Jap. p. 318. *Erigeron Thunbergii*, A. Gray, Bot. Jap. p. 395, and var. (?) *glabratum*, A. Gray, *l. c.*; Fr. & Sav. Enum. I, p. 227.

Hab. *Urup !* (*ex* Max.). *Shikotan*, in moist places on the side of a cliff.

Dr. Gray, in his notes on the Japanese plants collected in the Perry expedition, called our attention to a close affinity of the Simoda plant to *Aster unalaschensis*. Later, he made a remark on a larger and less hairy form collected by J. Small at Cape Shiriyazaki in the strait of Tsugaru, that it is the Japanese analogue of the Californian *Erigeron glaucus*. Examination of these original specimens in connection with my own collected on the eastern coast of Yezo and in Shikotan, shows a distinct similarity between them in all their important characters. No two specimens, however, are alike in the degree of the pubescence on their stalks and involucres. The Shikotan specimen is, for instance, almost smooth in its involucre, being simply ciliate on the margins; while in the Simoda plant it is densely villose, though not lanose. There is also some difference in the color of the pappus. All the specimens collected in the main island of Japan have a reddish, cinnamon-colored pappus; while those of the northern islands have a light, yellowish-brown one. But these differences are also seen to occur among a large number of the American specimens of *E. salsuginosus* in the Gray Herbarium.

The specimens collected at the Shiriyazaki have a general character just about intermediate between *E. glaucus* and *E. salsuginosus*. My Kurile and Yezo specimens, on the other hand, correspond very well with the typical *salsuginosus;* and through these northern plants one may safely refer those growing in the main island to the species under consideration, probably as its Japanese variety.

Distrib. Middle and northern Japan, the Kurile Islands to Alaska, thence southward along the higher mountains to California, Utah and New Mexico.

136. Anaphalis margaritacea, Benth. & Hook. Gen. Pl. II, p. 303; Gray, Synop. Fl. I, p. 233; Max. Mél. Biol. XI, p. 235. *Gnaphalium margaritaceum*, L.; Herd. Pl. Radd. III, 2, p. 102; Fr. & Sav. Enum. I, p. 242. *Antennaria margaritacea*, R. Br.; Ledeb. Fl. Ross. II, p. 613. *Antennaria cinnamomea*, Miq. Prol. p. 110.

Hab. Shikotan. Etorofu, at Furubetsu.

Distrib. Widely distributed throughout the cool temperate region of North America, extending northwestward to Alaska and the Aleutian Islands, and descending on the west coast along the higher mountains to Colorado and California. In Asia, it spreads over Kamtschatka, Saghalin, Japan and Manchuria; and as var. *cinnamomea* in Ceylon, Himalaya, upper Birma, and northwestern China; also in Manchuria and Japan, mixed with other forms.

137. Achillea Millefolium, L. Sp. p. 899; Ledeb. Fl. Ross. II, p. 531; A. Gray, Synop. Fl. I, p. 363.—Var. **occidentalis**, DC. Prodr. VI, p. 24; Herder, Pl. Radd. III, 2, p. 36. *A. borealis*, Bong. Veg. Sitcha, p. 149.

Hab. Kurile Islands (Merk. *ex* Herder).

This variable plant is very widely distributed throughout the subarctic and cool temperate regions of the northern hemisphere. In Japan, however, the plant has not yet been found in a wild state. A few plants were found around a new pasture ground in Sapporo in 1880. It is highly probable that they had been introduced there mixed with the seeds of grasses from America.

138. Achillea sibirica, Ledeb. in Ind. Sem. H. Dorpat., 1811, Fl. Ross. II, p. 528; Herd. Pl. Radd. III, 2, p. 37; Fr. & Sav. Enum. I, p. 233. *Ptarmica mongolica*, DC. Prod. VI, p. 22; Max. Prim. Fl. Amur. p. 154; F. Schm. Fl. Sach. p. 147. *A. multiflora*, Hook. Fl. Bor.-Am. I, p. 318.

Hab. Etorofu, at Furubetsu, Rubetsu and Shana.

Distrib. From the Baikal district of Siberia to Manchuria, northern China and Corea; and throughout the larger islands of Japan to Saghalin, Eastern Siberia, Kamtschatka and the Aleutian Islands; extending from Alaska eastward to the Saskatchewan.

The American *A. multiflora* can scarcely be distinguished from our *A. sibirica*, which is quite variable in size and the color of its rays and also in the shape of its leaves.

139. Achillea Ptarmica, L. Sp. p. 898; A. Gray, Synop. Fl. I, p. 363. *Ptarmica vulgaris*, Clus.; Ledeb. Fl. Ross. II, p. 529.—Var. **speciosa**, Herder, Pl. Radd. III, 2, p. 39. *A. speciosa*, DC. Prod. VI, p. 23; Ledeb. Fl. Ross. II, p. 530. *Ptarmica vulgaris*, F. Schm. Fl. Sach. p. 147.

Hab. Etorofu, at Furubetsu, Shibetoro and Rubetsu.

Distrib. Europe, northern Asia, and North America (New Brunswick). The variety in Kamtschatka and islands in the Behring Sea, across central and southern Siberia to middle Russia; also in Saghalin and the northern and middle provinces of Yezo.

140. Achillea macrocephala, Rupr. Fl. Samoj. in Beitr. zur Pfl. Kde. des Russ. R. II, p. 41; Trautv. Stirp. Sib. Coll. Bin. p. 450. *Ptarmica grandiflora*, DC. Prodr. VI, p. 23; Ledeb. Fl. Ross. II, p. 531.

Hab. Urup ! (*ex* Max.).

Distrib. Kamtschatka, the Kurile Islands and "Eastern Siberia" (*fide* Trautv.).

This plant is closely related to the preceding species, with which Herder proposed even to unite it. According to the descriptions given by De Candolle and Ruprecht, it differs from *A. Ptarmica*, var. *speciosa*, in the following characters:—teeth of the leaves more prominent and not incurvedly appressed; peduncle elongated; rays 8–9, obovate-elliptical; chaff on the receptacle oblong, serrate from the middle upward, fuscous, and subtrifid at the apex.

141. Chrysanthemum arcticum, L. Sp. ed. 2, p. 889; Hook. Fl. Bor.-Am. I, p. 319; A. Gray, Synop. Fl. I, p. 365. *Leucanthemum arcticum*, DC. Prodr. VI, p. 45; Ledeb. Fl. Ross. II, p. 541; Max. Prim. Fl. Amur. p. 155; Fr. & Sav. Enum. I, p. 234.

Hab. Urup! (*ex* Max.). *Etorofu*, on rocky cliffs at Tsurubetsu.

Professor Maximowicz kindly informs me that his Urup specimen is of "the large-headed form with pinnatifid leaves of Hakodate." My Etorofu plant is also of the same form.

Distrib. In northeastern Asia: coast regions of Manchuria, Saghalin, northern Japan; all around the Ochotsk Sea, Kamtschatka and adjacent islands to the Behring Strait. In North America, from arctic Alaska along the arctic shores to Hudson Bay; also in eastern Lapland, and arctic Russia.

142. Matricaria ambigua, Ledeb. Fl. Alt. IV, p. 118, and Fl. Ross. II, p. 547 (under *Pyrethrum*). *Chamœmelum limosum*, Max. Prim. Fl. Amur. p. 156. *Chamœmelon tetragonospermum*, F. Schm. Fl. Sach. p. 148. *Tripleurospermum ambiguum*, Fr. & Sav. Enum. I, p. 236. *Tripleurospermum inodorum*, var. *ambiguum*, Herder, Pl. Radd. III, 2, p. 42.

Hab. Shikotan, in grassy places about the harbor.

Distrib. Northern Europe and Asia, extending southward to southwestern Siberia and the Altai region, and to Manchuria, Saghalin and northern Japan; according to Herder also at Kotzebue Sound in Alaska.

143. Matricaria discoidea, DC. Prodr. VI, p. 50; Ledeb. Fl. Ross. II, p. 544; A. Gray, Synop. Fl. I, p. 364; Reg. & Til. Fl. Ajan. p. 102.

Hab. Urup! (*ex* Max.).

Distrib. Eastern Siberia in the Ochotsk region, Kamtschatka, and the Kurile Islands; through the Aleutian Islands and Alaska to western California, thence to Montana; now naturalized in the Atlantic states of North America, and in northern and middle Europe.

144. Artemisia laciniata, Willd. Sp. III, p. 1843; Besser, Tent. Abrot. p. 40; Ledeb. Fl. Ross. II, p. 581; Max. Mél. Biol. VIII, p. 530.—Var. **laciniata**, Max. *l. c.!*

Hab. Shikotan, on cliffs along the harbor.

Distrib. In Siberia from the Altai to the Ochotsk region; also in Dahuria, Mongolia, eastern Manchuria, and the southern Kuriles.

145. Artemisia glomerata, Ledeb. in Mém. Acad. Petersb. V, p. 564, Fl. Ross. II, p. 588; Bess. Abrot. p. 63; Max. Mél. Biol. VIII, p. 532; A. Gray, Synop. Fl. I, p. 370. *A. leontopodioides*, Fisch. *ex* Besser, Abrot. p. 63.

Hab. Kurile Islands! (Pallas *ex* Max.).

Distrib. Extreme northeastern Asia: Ochotsk region, Kamtschatka, the Kuriles and Tschuktches-land; also in arctic Alaska.

146. Artemisia norvegica, Fries; Besser, Abrot. p. 76; Max. Mél. Biol. VIII, p. 533; A. Gray, Synop. Fl. I, p. 371.—Var. **pacifica**, A. Gray, *l. c.* *A. longepedunculata*, Rudolphi ex Bess. Abrot. p. 77; Ledeb. Fl. Ross. II, p. 591. *A. arctica*, Less. in Linnæa, VI, p. 213; Ledeb. *l. c.* p. 591. *A. Chamissoniana*, Bess. in Hook. Fl. Bor.-Am. I, p. 324. *A. arctica*, var. *sachalinensis*, F. Schm. Fl. Sach. p. 150.

Hab. *Kurile Islands* (*ex* Turcz.).

Distrib. Eastern Siberia, northern Manchuria, Saghalin, Kamtschatka, and the Aleutian Islands to arctic Alaska. The typical form is found in the alpine region of Norway, in the northern Ural, and in the alpine and subalpine regions of western North America, as far south as California and southern Colorado.

147. Artemisia Stelleriana, Bess. Abrot. p. 79, t. 5; Ledeb. Fl. Ross. II, p. 592; Max. Mél. Biol. VIII, p. 534; F. Schm. Fl. Sach. p. 150; A. Gray, Synop. Fl. I, p. 371; Franchet, in Bull. Soc. Philom. Paris, avril, 1888. *A. Stelleriana*, var. *vesiculosa*, Fr. & Sav. Enum. II, p. 402. *A. chinensis*, Pursh, Fl. Bor.-Am. II, p. 521.

Hab. *Etorofu*, at Rausu.

Distrib. Along the coast of Kamtschatka, Saghalin and northern Japan; and also about the mouth of the Amoor in Manchuria. Found wild at Lynn Beach, Mass., North America, and also in Sweden (*fide* Areschoug, Fl. Dan., fasc. 51, t. 3045). According to Pursh, also on the northwestern coast of North America.

148. Artemisia vulgaris, L. Sp. p. 848; Bess. Abrot. p. 51; Ledeb. Fl. Ross. II, p. 585; Herd. Pl. Radd. III, 2, p. 74; Max. Mél. Biol. VIII, p. 535; A. Gray, Synop. Fl. I, p. 372; Fr. & Sav. Enum. I, p. 239.

Hab. *Shikotan*. *Etorofu*, common along the roadside thickets. *Shimushu* (Akakabe).

Distrib. Widely distributed in temperate Europe, Asia and western North America. Also found in the mountainous districts of India, Siam and Java. Naturalized in Canada and the Atlantic States of North America.

149. Artemisia sericea, Weber, in Stechm. Art. p. 16; Ledeb. Fl. Ross. II, p. 595; F. Schm. Fl. Sach. p. 150; Max. Mél. Biol. VIII, p. 537.

Hab. *Shikotan*, on rocky cliffs along the harbor.

All the specimens I have collected were in a sterile condition. The plant is suffruticose at the base and ascending, and is densely appressed-silky. The leaves are all petioled and coincide exactly with the sterile specimen of *A. sericea* from Dahuria (Fischer) in the Gray Herbarium!

Distrib. "From the R. Volga through Siberia to the R. Aldan in E. Siberia, Dahuria, Saghalin," and in the southern Kuriles.

150. Petasites japonicus, Miq. Prol. Fl. Jap. p. 380 (1867); Fr. & Sav. Enum. I, p. 220. *P. japonicus*, F. Schm. Fl. Sach. p. 145 (1868). *Tussilago Petasites*, Thunb. Fl. Jap. p. 314. *Nardosmia japonica*, Sieb. & Zucc. Fam. Nat. II, p. 57, n. 615. *Petasites spurius*, Miq. Prol. p. 100. *P. albus*, Gray, Pl. Jap. p. 314.—— Pallas, N. nord. Beitr. IV, p. 124.

Hab. From *Matowa*, the fourteenth island, southward (*ex* Pallas). *Shikotan*, on sheltered hillsides. *Etorofu*, in the vicinity of Furubetsu.

The plant grows throughout Japan and also in Saghalin. In a rich sheltered valley of northern Japan it often attains such a large size as to enable an average-sized person to walk under its spreading leaf without stooping. The description given by Pallas of the Kurile plant coincides perfectly with that of ours, and there is no doubt of their being the same.

151. Senecio Pseudo-Arnica, Less. in Linnæa, VI, p. 240; Ledeb. Fl. Ross. II, p. 642; A. Gray, Synop. Fl. I, p. 384; Max. Mél. Biol. VIII, p. 15; Fr. & Sav. Enum. II, p. 407.

Hab. *Etorofu*, at Ransu.

Distrib. Coast regions of Manchuria, Saghalin, Yezo, Eastern Siberia, Kamtschatka and islands in the Behring Sea; Alaska, and in Newfoundland to Grand Manan.

152. Senecio palmatus, Pall. Iter. III, p. 321; Ledeb. Fl. Ross. II, p. 636; Max. Prim. Fl. Amur. p. 166, Mél. Biol. VIII, p. 15. *S. cannabifolius*, Less. in Linnæa, VI, p. 242.

Hab. *Shumshu!* (*ex* Max., Aino name, *Oramakutu*). *Shikotan*, on hillsides.

Distrib. Eastern Siberia, Manchuria, Saghalin, northern and middle Japan, Kamtschatka and also at Sitka (*ex* Herder).

153. Senecio cacaliaefolius, Schultz Bip. in Flora, 1845, p. 50; Max. Mél. Biol. VIII, p. 14. *S. cacaliaeformis*, Reichb. f., Ic. Fl. Germ. XVI (1854), p. 43, t. 977; Fr. & Sav. Enum. I, p. 247. *Ligularia sibirica*, Cass.; Ledeb. Fl. Ross. II, p. 620. *L. speciosa*, Fisch. & Mey. Ind. Sem. H. Petrop. V, p. 38.

Hab. *Shikotan*, on hillsides. *Etorofu*, at Rubetsu.

Distrib. Arctic and alpine regions of Europe; Siberia to the Ochotsk region, Dahuria, Manchuria, northern China and Japan.

154. Senecio sagittatus, Schultz Bip. in Flora, 1845, p. 498; Max. Mél. Biol. IX, p. 292. *Cacalia hastata*, L.; Ledeb. Fl. Ross. II, p. 626; A. Gray, Bot. Jap. p. 395; Herd. Pl. Radd. III, 2, p. 107 (excl. pl. Sitka, *fide* Gray).

Hab. *Etorofu*, at Furubetsu.

Distrib. Kamtschatka and adjacent islands; throughout Siberia to northern and eastern Russia in Europe, Dahuria, Mongolia, Manchuria, Corea, and middle and northern Japan and Saghalin.

155. Senecio davuricus, Schultz Bip. in Flora, 1845, p. 499; Max. Mél. Biol. IX, p. 296. *Cacalia auriculata*, DC. Prod. VI, p. 329; Max. Prim. Fl. Amur. p. 165; Ledeb. Fl. Ross. II, p. 627.—Var. **kamtschaticus**, Max. *l. c.*

Hab. *Shumshu!* (*ex* Max., Aino name, *Hobenakina*).

Distrib. Kamtschatka, the Ochotsk district, Yezo, Saghalin, and Manchuria to eastern Dahuria.

156. Cnicus kamtschaticus, Max. Mél. Biol. IX, p. 310; A. Gray, Synop. Fl. I, p. 399. *Cirsium kamtschaticum*, Ledeb. in DC. Prodr. VI, p. 644, Fl. Ross. II, p. 736; Herder, Pl. Radd. III, 4, p. 4.

Hab. *Shumshu!* and *Paramushir!* (*ex* Max., Aino name, *Katamashatshi*).

Distrib. In Kamtschatka and the Aleutian Islands. As var. (?) *Grayanus*, Max., in

the island of Yezo. In Saghalin, a nearly related species, *Cnicus Weyrichii*, Max., is found. The Kurile plants have white flowers.

157. Picris japonica, Thunb. Fl. Jap. p. 299; Ledeb. Fl. Ross. II, p. 800; Max. Prim. Fl. Amur. p. 177; Fr. & Sav. Enum. I, p. 268. *P. kamtschatka*, Ledeb. in Mém. Acad. Petersb. v, p. 557. *P. dahurica*, DC. Prodr. VII, p. 129. *P. davurica*, Fisch. & Hornem. H. Hafn. Suppl., p. 155. *Picris hieracioides*, var. *japonica*, Regel, Pl. Radd. III, 4, p. 25.

Hab. Urup! (*ex* Max.). *Etorofu*, at Furubetsu.

Distrib. Japan, Saghalin, Manchuria, Siberia to the Altai districts, northern China, and Kamtschatka to Sitka in Alaska.

158. Taraxacum lyratum, DC. Prodr. VII, p. 148; Ledeb. Fl. Ross. II, p. 816; F. Schm. Fl. Sach. p. 154. *Taraxacum officinale*, Wigg., var. *alpinum*, Koch, lus., *lyratum*, Herd. Pl. Radd. III, 4, p. 43.

Hab. Kurile Islands (*ex* Turcz.)—"scapis glabris."

Distrib. Altai and Baikal districts of Siberia, Saghalin, Kamtschatka and the Aleutian Islands.

159. Lactuca Thunbergii, Benth.; Max. Mél. Biol. IX, p. 361. *Ixeris Thunbergii*, A. Gray, Bot. Jap. p. 397; Miq. Prol. p. 123. *Prenanthes dentata*, Thunb. Fl. Jap. p. 301.

Hab. Etorofu, at Furubetsu.

Distrib. Japan: from Kiusiu to northern Yezo.

160. Lactuca repens, Benth.; Max. Mél. Biol. IX, p. 364. *Ixeris repens*, A. Gray, Bot. Jap. p. 397; Benth. Fl. Hongk. p. 194; Fr. & Sav. Enum. I, p. 271. *Chorisis repens*, DC. Prod. VII, p. 178. *Nabalus repens*, Ledeb. Fl. Ross. II, p. 840.

Hab. Kurile Islands! (*ex* Max.). *Etorofu*, at Rausu.

Distrib. Kamtschatka, Saghalin, Japan, Manchuria, Corea, China.

161. Lactuca sibirica, Benth.; Max. Mél. Biol. IX, p. 357. *Mulgedium sibiricum*, Less. Syn. p. 142; Ledeb. Fl. Ross. II, p. 843; Herder, Pl. Radd. III, 4, p. 72.

Hab. Paramushir! at a lake (*ex* Max.). *Etorofu*, at Tsurubetsu.

Distrib. Northern and eastern Europe, Siberia, Manchuria, Saghalin, Yezo (middle and northern) and Kamtschatka.

162. Sonchus arvensis, L., var. **uliginosus**, Trautv. Pl. Schrenk. no. 715; Herder, Pl. Radd. III, 4, p. 46; Fr. & Sav. Enum. I, p. 275. *Sonchus uliginosus*, M. a. B.; Ledeb. Fl. Ross. II, p. 834. *S. maritimus*, L.; Ledeb. *l. c.* p. 835; F. Schm. Fl. Sach. p. 154. *S. brachyotus*, DC. Prodr. VII, p. 186; Max. Prim. Fl. Amur. p. 181.

Hab. Shikotan, on the beach at the foot of a rocky cliff.

Distrib. From middle and eastern Europe through the southern districts of Siberia and Dahuria to northern China and Manchuria, Saghalin and Japan.

CAMPANULACEÆ.

163. Campanula rotundifolia, L., var. **arctica** Lange, Fl. Dan. XVI, p. 8, t. 7211; A. Gray, Synop. Fl. II, Suppl. p. 395. *C. linifolia*, Lam.; Ledeb. Fl. Ross. II, p. 888. *C. Scheuchzeri*, A. Gray, Synop. Fl. II, p. 12. *C. linifolia*, var. *Langsdorffiana*, DC. Prodr. VII, 2, p. 471.

Hab. *Urup!* (Mertens).

Distrib. Arctic and alpine Europe; from the Altai region of Siberia to the Ochotsk district; Saghalin, Alaska, in the Rocky Mountains to Colorado, east to Newfoundland and Labrador; Greenland.

164. **Adenophora verticillata**, Fisch. in Mém. Soc. Nat. Mosc. VI, p. 167; Ledeb. Fl. Ross. II, p. 892; Fr. & Sav. Enum. I, p. 278, II, p. 422. *Campanula tetraphylla*, Thunb. Fl. Jap. p. 87.

Hab. *Etorofu*, at Tsurubetsu. My specimen is too young to determine the variety. It has four smooth obovate leaves in a whorl.

Distrib. Baikal-Siberia, Dahuria, Manchuria, Saghalin and Japan.

ERICACEÆ.

165. **Vaccinium Oxycoccus**, L. Sp. p. 351; A. Gray, Synop. Fl. II, p. 25; Max. Mél. Biol. VIII, p. 614; Pallas, Fl. Ross. I, 2, p. 47.

Hab. *Kurile Islands* (*ex* Pallas).

Dr. Gray, in the supplement to his Synoptical Flora (II, p. 396), refers the plants from Japan, Saghalin, northeastern Asia, and also from Washington Territory and northern Oregon, having larger and obtuse leaves, and flowers which are strictly umbellate from the scaly bud, to his new var. *intermedium*. Among the Hakodate specimens collected by J. Small there is one which has a leafy shoot starting from the flower-bearing bud, approaching *Vaccinium macrocarpon* in general appearance.

Distrib. In sphagnous swamps in the subarctic and alpine regions of Europe, northern Asia and North America.

166. **Vaccinium Vitis-Idaea**, L. Sp. p. 351; A. Gray, Bot. Jap. p. 397, Synop. Fl. II, p. 25; Max. Mél. Biol. VIII, p. 605; Pallas, Fl. Ross. I, 2, p. 46.

Hab. *Kurile Islands* (*ex* Pallas); *Shumshu* (J. Akakabe); *Shikotan; Etorofu*, at Furubetsu, Arimoi and Shibetoro.

Distrib. All around the arctic circle, descending southward in Europe to the alpine regions of the Mediterranean border, and to the Caucasus; and in Asia, to the Altai Mountains and Dahuria, and to the alpine region of Kinsiu in Japan; in North America, to British Columbia in the west, and to northern New England in the east.

167. **Vaccinium praestans**, Lamb. in Trans. Linn. Soc. X, p. 264, t. 9; Ledeb. Fl. Ross. II, p. 904; Max. Prim. Fl. Amur. p. 187, t. 8, f. 19–23, Mél. Biol. XII, p. 489; F. Schm. Fl. Sach. p. 156.

Hab. *Shikotan*, in exposed grassy places on top of cliffs. *Etorofu*, at Furubetsu.

Distrib. Kamtschatka (western coast, J. Small); northeastern Manchuria; Saghalin, Yezo (Otsnishi, Prov. Nemuro!); and in the alpine regions of middle Japan.

168. **Vaccinium uliginosum**, L. Sp. p. 350; Ledeb. Fl. Ross. II, p. 904; Pallas, Fl. Ross. I, 2, p. 45; Max. Mél. Biol. VIII, p. 605; A. Gray, Synop. Fl. II, p. 22.

Hab. *Kurile Islands* (*ex* Pallas).

Distrib. In the arctic, alpine and subalpine regions of Europe; northern Asia, extending to middle Japan in the east; and in North America throughout arctic and British America coming down to Oregon in the west, and to New England and New York in the east.

169. Vaccinium hirtum, Thunb. Fl. Jap. p. 155; Max. Mél. Biol. VIII, p. 605; Fr. & Sav. Enum. I, p. 605.—Var. **Smallii**, Max. *l. c.* *Vaccinium Smallii*, A. Gray, Bot. Jap. p. 398; F. Schm. Fl. Sach. p. 156.

Hab. *Etorofu*, at Furubetsu and Arimoi.

Distrib. Southern Saghalin to Kiusiu in Japan.

170. Arctostaphylos Uva-ursi, Spreng. Syst. Veg. II, p. 287; Ledeb. Fl. Ross. II, p. 909; F. Schm. Fl. Sach. p. 157; A. Gray, Synop. Fl. II, p. 27. *Arbutus Uva-ursi*, L. Sp. p. 395; Pallas, Fl. Ross. I, 2, p. 48.

Hab. *Kurile Islands* (*ex* Pallas).

Distrib. Arctic and alpine Europe; northern Asia, especially in the mountain districts of southern Siberia, northern Saghalin, eastern Siberia and Kamtschatka; Alaska in North America, where it spreads over the arctic and northern regions descending along the higher mountains to New Mexico and northern California in the west, and to Pennsylvania in the east.

171. Cassiope lycopodioides, Don, in Edinb. N. Phil. Journ. XVII, p. 157; Ledeb. Fl. Ross. II, p. 912; Max. Mél. Biol. VIII, p. 614; Fr. & Sav. Enum. I, p. 285; A. Gray, Synop. Fl. II, p. 36. *Andromeda lycopodioides*, Pallas, Fl. Ross. I, 2, p. 55, t. 73, f. 1.

Hab. *Shumshu* (Hakodate Museum).

Distrib. Eastern Siberia in the Ochotsk district; Kamtschatka; Yezo (Volc. Talmai, Prov. Iburi) to middle Japan; Aleutian Islands to Oregon in North America.

172. Leucothoe Grayana, Max.! Mél. Biol. VIII, p. 613; Fr. & Sav. Enum. I, p. 284. *L. chlorantha*, A. Gray, Bot. Jap. p. 399 (not DC.).

Hab. *Shikotan*, on hillsides.

The plant is common in the mountain woods of Yezo on both the eastern and western coasts. It comes down as far south as middle Japan, where it is found only in the alpine woods.

173. Bryanthus taxifolius, A. Gray, Proc. Am. Acad. VII, p. 368, Synop. Fl. II, p. 37. *Phyllodoce taxifolia*, Salisb. Parad. Lond. t. 56; Ledeb. Fl. Ross. II, p. 916; Max. Rhod. As. Or. p. 6.

Hab. *Paramushir!* (*ex* Max.).

Distrib. Northern Europe and the central Pyrenees; Altai and Baikal districts of Siberia, Dahuria, northern Manchuria, eastern Siberia, Kamtschatka, northern and middle Japan; Aleutian Islands, Copper Island; and also on the alpine mountain summits of northern New England and Canada, Labrador, Greenland.

174. Rhododendron chrysanthum, Pall. It. III, p. 729, t. IV, f. 1–2; Ledeb. Fl. Ross. II, p. 920; Max. Prim. Fl. Amur. p. 189, Rhod. As. Or. p. 20.

Hab. *Shumshu!* (*ex* Max.).

Distrib. Altai and Baikal districts of Siberia, Dahuria, northeastern Manchuria, eastern Siberia, Kamtschatka, and adjacent islands to Sitka; Saghalin, northern and middle Japan, Yezo (L. Böhmer), Tateyama, Prov. Etchu (Yatabe).

175. Rhododendron kamtschaticum, Pall. Fl. Ross. I, p. 48, t. 33; Ledeb. Fl. Ross. II, p. 922; Max. Rhod. As. Or. p. 41; A. Gray, Synop. Fl., II, p. 40.

Hab. *Urup!* (*ex* Max.). *Shikotan*, on rocky cliffs along the harbor.

Distrib. Eastern Siberia, in the Ochotsk district and Tschuktches-land, Kamtschatka, Saghalin and northern Japan, the Aleutian Islands and Alaska.

176. **Ledum palustre**, L. Sp. p. 591; Ledeb. Fl. Ross. II, p. 923; Max. Rhod. As. Or. p. 49; A. Gray, Synop. Fl. II, p. 43.—Var. **dilatatum**, Wahlbg. Fl. Lapp. p. 103.

Hab. Shikotan, on hillsides.

Distrib. Eastern Siberia, northeastern Manchuria, Saghalin, Yezo to the alpine region of southern Japan, Kamtschatka to Sitka in Alaska, and also in the Altai mountains and northern Europe. The species is widely distributed throughout the arctic and cool temperate regions of the northern hemisphere.

177. **Pyrola renifolia**, Max. Prim. Fl. Amur. p. 190, Mél. Biol. VIII, p. 634; F. Schm. Fl. Sach. p. 158; Fr. & Sav. Enum. I, p. 295.

Hab. Etorofu, on the Arimoi side of Nohori.

The plant is commonly found in the mountain woods of Yezo, Saghalin and eastern Manchuria. It occurs also in the higher mountains of middle Japan.

178. **Pyrola media**, Swartz in Act. Holm. 1804, p. 257, f. 7; Ledeb. Fl. Ross. II, p. 929; Hook. f. Stud. Flora, 3rd ed. p. 255; A. Gray, Bot. Jap. p. 400; Max. Mél. Biol. Biol. p. 625.

Hab. Etorofu, at Shibetoro.

The plant approaches nearer in all its characters to the European *P. media* than to our *P. minor* or *rotundifolia*. The stamens are erect, and shorter than the nearly straight stout style; the stigmatic lobes are minute and erect, and are provided with a distinct ring around their base; and the anthers are not narrowed below the pores. The bracts are larger than in *P. minor*, and are longer than the pedicels. A specimen collected by C. Wright at Simoda is in bud. Compared with my plant the style is longer and deflexed, and the anthers are larger, even in the bud, and somewhat narrowed beneath the openings.

179. **Pyrola minor**, L. Sp. p. 396; Ledeb. Fl. Ross. II, p. 930; A. Gray, Bot. Jap. p. 400, Synop. Fl. II, p. 46; Herder, Pl. Radd. IV, p. 80; Max. Mél. Biol. VIII, p. 652.

Hab. Kurile Islands! (herb. Pallas). *Etorofu*, at Furubetsu.

Distrib. Europe, northern Asia, and northern North America. In eastern Asia it comes down through Saghalin and Yezo to the alpine woods of middle Japan. In North America it extends to Oregon and New Mexico, and to the White Mountains.

180. **Pyrola secunda**, L. Sp. p. 396; Ledeb. Fl. Ross. II, p. 930; Max. Mél. Biol. VIII, p. 625; A. Gray, Synop. Fl. II, p. 46; F. Schm. Fl. Sach. p. 158.

Hab. Etorofu, at Furubetsu.

Distrib. Europe, northern Asia, Manchuria to the border of Corea, Saghalin, and northern and middle Japan; British America to Colorado and California, and to New England and New York, and also in Mexico.

DIAPENSIACEÆ.

181. **Diapensia lapponica**, L. Sp. p. 141; Ledeb. Fl. Ross. III, p. 85; Trautv. & Mey. Fl. Ochot. p. 69; F. Schm. Fl. Sach. p. 161; A. Gray, Bot. Jap. p. 400; Herder, Pl. Radd. IV, 1, p. 205.

Hab. Shumshu (Hakodate Museum).

Herder remarks that the plants found in northeastern Asia (Saghalin, Ochotsk district, Tschuktches-land, Kamtschatka and the adjacent islands) have characters in common with Schmidt's var. *obovata*. As I have not at this moment the Shumshu specimen at hand, I cannot say anything definite about its relation to the Saghalin plant. Wright's specimen from Hakodate and Tschonoski's (*D. lapponica*, var. *asiatica*, Max.) from Nambu in northern Japan have their leaves distinctly marked with reticulated veins on their upper surface and broadly spatulate in shape. In one of the Hakodate specimens there is a sterile branch which has leaves all tapering into slender stalks and obovate-cuneate in form. The Saghalin and Japanese specimens seem to me alike, and should be put under the same variety of *D. lapponica*. The typical form of this species is found in the arctic and subarctic regions of Europe, Greenland, and eastern North America, descending to the alpine districts of northern New England.

PLUMBAGINACEÆ.

182. Armeria vulgaris, Willd. Enum. I, p. 333; Herder, Pl. Radd. in Act. Hort. Petrop. x, 1, p. 53; A. Gray, Synop. Fl. II, p. 55. *Statice Armeria*, L.; Ledeb. Fl. Ross. III, p. 456.—Forma **arctica**, Herd. l. c.

Hab. Kurile Islands (Pallas, *ex* Herder).

This polymorphous species is widely distributed in Europe and northern Asia, especially in the northeastern portion; and in North America from Labrador across the arctic region to Alaska, descending along the Pacific coast to California, and occurring again in Chili and Patagonia.

PRIMULACEÆ.

183. Dodecatheon Meadia, L., var. **brevifolium**, A. Gray, Bot. Calif. I, p. 467, Synop. Fl. II, p. 57. *D. ellipticum*, Nutt. *ex* Durand, Pl. Pratt. in Journ. Acad. Phil. II. ser. II, p. 95; A. Gray, Bot. Gaz. XI, p. 232.

Hab. Urup! (*ex* Max.).

Distrib. Most common in western California, spreading to Utah, and also to British Columbia and farther up to Bering Strait and the Kurile Islands.

184. Primula cuneifolia, Ledeb. in Mém. Acad. Petersb. v, p. 522, Fl. Ross. III, p. 15; Regel & Til. Fl. Ajan. p. 111; A. Gray, Synop. Fl. II, p. 59; Franchet in Bull. Soc. Philomath. Paris, May, 1886, and April, 1888.

Hab. Shumshu! Paramushir! and *Urup!* (*ex* Max.).

Distrib. Eastern Siberia along the Ochotsk Sea, Kamtschatka and northern Japan; the Aleutian Islands and Alaska.

185. Primula farinosa, L., Ledeb. Fl. Ross. III, p. 13; Regel, Pl. Nov. Turk. fasc. II, p. 41; A. Gray, Synop. Fl. II, p. 58.—Var. **Fauriae**. *P. Fauriæ*, Franch. l. c.; Pax in Engler Bot. Jahrb. 1888, p. 211. *P. farinosa*, var. *armena*, Pax, l. c., p. 199 (in part). *P. farinosa*, var. *luteo-farinosa*, Fr. & Sav. Enum. II, p. 429.

Hab. Shikotan, on rocky cliffs along the harbor. *Etorofu*, at Tsurubetsu.

The leaves are ovate to rhombic-orbicular, more or less abruptly cuneate, tapering into an elongated margined petiole, toothed, crenate, or nearly entire; scape two or three times the length of the leaf; bracts lanceolate-subulate, somewhat gibbose at base, and three to six times shorter than the glabrous pedicels; umbel few- to several-flowered, generally 6–7-flowered; calyx campanulate and parted to the middle; teeth obtuse or subacute; and the tube of the corolla about one and one-half times the length of the calyx. According to Franchet the capsule is twice the length of the calyx.

Our plants coincide exactly with the descriptions of *P. Faurie*, Franch., and I have no doubt of their being identical, though my specimens have no fully ripened capsules for comparison. From the continental var. *armena*, our plant differs in the rounded blades of the leaves and longer pedicels. Whether the capsule of the former is also as long as ours or not I have no means of determining at present either from the specimens or from the descriptions. The size of the capsule in *P. farinosa* seems to be quite variable. In some of the European, and especially in the American plants, the capsule often attains the size of about twice the length of the calyx. Pax wrongly included *P. Faurie* and also *P. macrocarpa*, Max., under his new sect. *Macrocarpæ*. These plants properly belong to his sect. *Farinosæ*. Their flowers are not so large as those of *P. cuneifolia*, and their bracts are somewhat gibbose. The younger leaves in the specimens of *P. macrocarpa* in the Gray Herbarium show distinctly the yellow powder on their under surface, though the older leaves and calyx are completely naked. The plant is hardly distinguishable from the American *P. mistassinica*, Michx. (*P. farinosa*, var. *mistassinica*, Pax), either the shape and size of the flowers and capsules, or by the character of the leaves and their teeth.

The species is very variable and widely distributed in the arctic and cool temperate regions of Europe, northern Asia and North America, and also in antarctic America.

186. Androsace villosa, L. Sp. p. 142; Ledeb. Fl. Ross. III, p. 17; Max. Mél. Biol. XII, p. 753.—Var. **latifolia**, Ledeb. Fl. Alt. I, p. 218; Herder, Pl. Radd. IV, 1, p. 118; Max. l. c. *A. Chamæjasmeæ*, Koch, Syn. p. 584; Ledeb. Fl. Ross. III, p. 18; Reg. & Til. Fl. Ajan., p. 111; A. Gray, Synop. Fl. II, p. 60.

Hab. Kurile Islands (*ex* Chamisso).

Distrib. Arctic and alpine regions of Europe and North America (from Colorado northward), the Aleutian Islands, Kamtschatka, extreme eastern Siberia to the Trans-Baikal district, northwestern China, northern Thibet, the Altai mountains and northern Ural.

187. Trientalis europaea, L. Sp. p. 344; Ledeb. Fl. Ross. III, p. 24; Fr. & Sav. Enum. II, p. 430; Herd. Pl. Radd. IV, 1, p. 131; A. Gray, Synop. Fl. II, p. 61.

Hab. Paramushir, Urup, etc.! (*ex* Max.). *Etorofu*, at Rubetsu.—Var. *arctica*, Ledeb. l. c., in the *Kurile Islands* (herb. Fisch., *ex* Herder).

Distrib. Widely spread in Europe from the arctic region to the northern Alps; in northern Asia to the Bering Sea and Manchuria, descending in Japan to the alpine district of the main island; and in North America, from Alaska southward to the mountains of Oregon and California.

GENTIANACEÆ.

188. Crawfurdia japonica, Sieb. & Zucc. Fl. Jap. Fam. Nat. II, p. 36, n. 546; Miq. Prol. Fl. Jap. p. 288; Fr. & Sav. Enum. I, p. 324; C. B. Clarke in Hook. f. Fl. Brit. Ind. IV, p. 107. *Golowninia japonica*, Max. Mél. Biol. IV, p. 41, t. 4.

Hab. *Etorofu*, at Furubetsu.

Distrib. Japan, China, Formosa, Sikkim, Himalaya.

189. Gentiana auriculata, Pall. Fl. Ross. II, p. 102, t. 92, f. 1; Ledeb. Fl. Ross. III, p. 55; Herder, Pl. Radd. IV, 1, p. 149; A. Gray, Synop. Fl. II, p. 118; F. Schm. Fl. Sach. p. 160.

Hab. *Kurile Islands* (Herder, *ex* Georgi). *Urup !* and elsewhere (*ex* Max.).

Distrib. Saghalin, northeastern Manchuria, Ochotsk district, Kamtschatka and adjacent islands, to Alaska?

190. Gentiana glauca, Pall. Fl. Ross. II, p. 104, t. 93, f. 2; Griseb. in DC. Prodr. IX, p. 111; Ledeb. Fl. Ross. III, p. 66; A. Gray, Synop. Fl. II, p. 120; Herder, Pl. Radd. IV, 1, p. 172.—Var. **major**, Ledeb., l. c.

Hab. *Urup !* (*ex* Max.).

Distrib. Eastern Siberia from the northern Jabbonoi-Chrebet through the Ochotsk region to Teshuktches-land and Kamtschatka. In North America, from arctic Alaska along the higher and northern Rocky Mountains to Oregon.

191. Swertia perennis, L. Sp. p. 226; A. Gray, Synop. Fl. II, p. 124. *S. obtusa*, Ledeb. in Mém. Acad. Petersb. V, p. 526, and Fl. Ross. III, p. 75; F. Schm. Fl. Amg. Bur. p. 56.—Var. **obtusa**, Griseb. in DC. Prodr., IX, p. 132; Trautv. & Mey., Fl. Och., p. 68; Herder, Pl. Radd., IV, 1, p. 188.

Hab. *Kurile Islands* (herb. Fisch., *ex* Herder).

Distrib. This species is widely distributed throughout a greater part of the temperate regions of Europe and in northern and central Asia and also in northwestern and western North America. Our present variety is chiefly northern Asiatic and western North American in its range of distribution; and as var. *cuspidata*, Max. (Mél. Biol., IX, p. 398), in the alpine region of middle Japan.

192. Swertia tetrapetala, Pall. Fl. Ross. II, p. 99, t. 90, f. 2. *Stellera cyanea*, Turcz. in Bull. Mosc. 1840, p. 167; Ledeb. Fl. Ross. III, p. 72. *Rellesta cyanea*, Turcz. Fl. Baic.-Dah. II, 2, p. 270; Max. Prim. Fl. Amur. p. 198. *Ophelia papillosa*, Fr. & Sav. Enum. II, p. 450.

Hab. *Kurile Islands* (Steller, *ex* Turcz., etc.). *Urup !* and elsewhere (*ex* Max.). *Shikotan*, grassy places on top of cliffs along the harbor. *Etorofu*, at Furubetsu and Shibetoro.

Distrib. Eastern Siberia around the Ochotsk Sea; northeastern Manchuria; Kamtschatka, and through the Kurile Islands to the eastern coast of Yezo; Samani Sands, Province Hidaka (K. M., Aug. 19, 1884, fl.); Yubutsu, Prov. Iburi (K. M., Aug. 23, 1884, fl.).

193. Menyanthes trifoliata, L. Sp. p. 145; Ledeb. Fl. Ross. III, p. 76; Fr. & Sav. Enum. p. 325; A. Gray, Synop. Fl. II, p. 128.

Hab. *Paramushir!* (*ex* Max.).

Distrib. Widely distributed in the arctic and cool temperate regions of Europe, Asia and North America.

BORRAGINACEÆ.

194. Cynoglossum furcatum, Wall. in Roxb. Fl. Ind. II, p. 6; Max. Mél. Biol. VIII, p. 554; C. B. Clarke in Hook. f. Fl. Brit. Ind. IV, p. 155; Fr. & Sav. Enum. I, p. 336.

Hab. *Etorofu*, at Furubetsu.

Distrib. Throughout Japan, from northern Yezo to Kiusiu, and in the mountains of India, Ceylon and northern Afghanistan.

195. Mertensia maritima, G. Don, Syst. IV, p. 320; Ledeb. Fl. Ross. III, p. 132; Max. Mél. Biol. VIII, p. 532; A. Gray, Bot. Jap. p. 403, and Synop. Fl. II, p. 200; Herd. Pl. Radd. IV, 1, p. 226.

Hab. *Kurile Islands!* (herb. Fisch.).

Distrib. Arctic and northern Europe, Asia and North America, descending in eastern Asia to the northern provinces of the main island of Japan, and in North America to Washington Territory on the west coast, and to Cape Cod on the east.

196. Mertensia stylosa, DC. Prod. X, p. 91; Ledeb. Fl. Ross. III, p. 135; Herd. Pl. Radd. IV, 1, p. 231.

Hab. "*Kurile Islands?* (Steller, *ex* Pallas in Willd. herb.)."

Distrib. Subalpine region of Baikal-Siberia, Dahuria and eastern Siberia (on the mountains of Ishiga).

197. Mertensia paniculata, Don, Syst. IV, p. 318; A. Gray, Synop. Fl. II, p. 201; Herder, Pl. Radd. IV, 1, p. 229. *Mertensia pilosa*, DC. Prodr. X, p. 90; Ledeb. Fl. Ross. III, p. 134. *Steenhammera pilosa*, Turcz. in Bull. Mosc. 1840, p. 249. *M. pubescens*, DC. Prodr. X, p. 90.

Hab. *Kurile Islands* (Steller, *ex* Pallas in Willd. herb., and herb. Pallas, *ex* Herder). *Shumshu!* etc. (*ex* Max.).

Distrib. "Hudson's Bay and Lake Superior, thence to the Rocky Mountains (south to Utah and Nevada), Alaska, Behring Straits;" Kamtschatka and the Kuriles.

198. Mertensia rivularis, DC. Prodr. X, p. 90; Ledeb. Fl. Ross. III, p. 135; Herder, Pl.; Radd. IV, 1, p. 232; Max. Mél. Biol. VIII, p. 543. *Lithospermum rivulare*, Turcz. in Bull. Mosc. 1840, p. 74. *Steenhammera rivularis*, Turcz., *l. c.* p. 248.

Hab. *Kurile Islands* (Orloff, *ex* Herder).

Distrib. Northern Manchuria, eastern Siberia in the Ochotsk district; and Kamtschatka and adjacent islands.

199. Mertensia sibirica, G. Don, Gen. Syst. IV, p. 319; A. Gray, Synop. Fl. II, p. 200. *M. denticulata*, G. Don, l. c.; DC. Prodr. X, p. 90; Ledeb. Fl. Ross. III, p. 133. *Pulmonaria denticulata*, Chamisso in Linnæa, VI, p. 448. *Steenhammera pterocarpa*, Turcz. in Bull. Mosc. 1840, p. 245?

Hab. *Kurile Islands?* (*ex* Turcz.).

Distrib. Northern and eastern Siberia, Kamtschatka, arctic Alaska, and along the higher mountains southward to Colorado and California.

200. **Myosotis intermedia**, Link, Enum. Hort. Berol. I, p. 164; DC. Prodr. X, p. 108; Ledeb. Fl. Ross. III, p. 146; Max. Mél. Biol. VIII, p. 545. *M. arvensis*, L.; A. Gray, Pl. Jap. p. 316.

Hab. *Shikotan*, on hillsides.

Distrib. Europe, northern Africa, Siberia (excl. eastern Siberia), to northern Afghanistan and subalpine Kashmir; northern Japan.

SCROPHULARIACEÆ.

201. **Linaria japonica**, Miq. Prol. Fl. Jap. p. 47; Fr. & Sav. Enum. I, p. 342. *L. geminiflora*, F. Schm.! Fl. Sach. p. 161; Herder, Pl. Radd. IV, 1, p. 293.

Hab. *Shikotan*, on sandy beach.

Distrib. Along the coast-regions of Japan, especially common northward. Saghalin, Manchuria.

202. **Scrophularia alata**, A. Gray, Bot. Jap. p. 101; Miq. Prol. Fl. Jap. p. 47; F. Schm. Fl. Sach. p. 162; Herder, Pl. Radd., IV, 1, p. 294; Fr. & Sav. Enum. I, p. 342.

Hab. *Shikotan*, moist places at the foot of cliffs along the harbor. *Etorofu*, at Tsurubetsu.

Distrib. Along the coast region of northern and middle Japan, Saghalin and Manchuria (*ex* Herder).

203. **Mimulus ringens**, L. Sp. p. 634; Ledeb. Fl. Ross. II, p. 223; Georgi, Beschr. Russ. Reich. III, p. 1113; A. Gray, Synop. Fl. II, p. 276, Suppl. p. 446.

Hab. *Kurile Islands?* (Merk., *ex* Georgi).

Distrib. Canada and eastern United States to Iowa, south to Texas, and north to the Hudson's Bay district.

204. **Veronica longifolia**, L. Sp. p. 10; Ledeb. Fl. Ross. III, p. 232; Max. Prim. Fl. Amur. p. 207; Fr. & Sav. Enum., I, p. 348.

Hab. *Kurile Islands!* (*ex* Max.)

Distrib. Japan, Saghalin, Manchuria and eastern Siberia, westward through northern Asia to the Atlantic coasts in Europe.

205. **Veronica Beccabunga**, L., var. **americana**, Glehn, *ex* Max. Mél. Biol. XI, p. 278. *V. americana*, Schwein.; Benth. in DC. Prodr. X, p. 468; A. Gray, Synop. Fl. II, p. 287; Herd. Pl. Radd, IV, 2, p. 20. *V. Beccabunga*, F. Schm. Fl. Sach. p. 163.

Hab. *Kurile Islands!* (*ex* Max.). *Etorofu*, at Tsurubetsu.

Distrib. Throughout Yezo, Saghalin, Kamtschatka, the Aleutian Islands, Alaska to California and New Mexico, Canada and the northern Atlantic States.

206. **Veronica aphylla**, L., var. **grandiflora**, Benth. in DC. Prodr. X, p. 476; Ledeb. Fl. Ross. III, p. 245; Herd. Pl. Radd. IV, 2, p. 32. *V. grandiflora*, J. Gärtn. in Comment. Ac. Petrop. XIV, p. 531, t. 18, f. 1. *V. kamtschatica*, L. f. Suppl. p. 83; A. Gray, Synop. Fl. II, p. 287.

Hab. *Kurile Islands* (*ex* Chamisso).

Distrib. Kamtschatka and adjacent islands to the Aleutian Islands (Kiska).

The typical form of this species is found in the alpine districts of Europe.

207. Veronica Stelleri, Pall.; Rœm. & Sch. Syst. Mant. I, p. 102; Benth. in DC. Prodr. X, p. 481; Ledeb. Fl. Ross. III, p. 247; A. Gray, Synop. Fl. II, p. 288; Max. Mél. Biol. XII, p. 501.

Hab. *Kurile Islands* (Pall.). *Shumshu!* etc. (*ex* Max.).

Distrib. Aleutian Islands; Kamtschatka; Saghalin; Yezo; Shikaribetsu in Tokachi (S. Tanouchi), and in the alpine region of middle Japan.

208. Veronica serpyllifolia, L. Sp. p. 12; Benth. in DC. Prodr. X, p. 482; Ledeb. Fl. Ross. III, p. 248; Turcz. Fl. Baic.-Dah., II, 2, p. 346; A. Gray, Synop. Fl., II, p. 288.

Hab. *Kurile Islands* (*ex* Turcz.). *Urup!* (*ex* Max.).

Distrib. Widely distributed in Europe, northern and southern Africa, northern and middle Asia, a greater part of temperate North America, and in the higher mountains of western South America; Falkland Islands. In Japan it has so far been found only in the island of Yezo.

209. Euphrasia officinalis, L. Sp. p. 604; Ledeb. Fl. Ross. III, p. 262; A. Gray, Synop. Fl. II, p. 305; Fr. &. Sav. Enum. I, p. 351.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Japan, Saghalin, Kamtschatka, eastern Siberia, Manchuria, westward through northern and central Asia to Europe; Greenland, Labrador to the alpine regions of New England and westward to the northern Rocky mountains and Alaska.

210. Pedicularis Chamissonis, Stev. Monograph. p. 20, t. 4, f. 1; Bunge in Ledeb. Fl. Ross. III, p. 274; Max. Mél. Biol. X, p. 90, XI, p. 284, and XII, p. 858, t. 5, f. 90; A. Gray, Synop. Fl. II, p. 306.

Hab. *Shumshu!*, *Paramushir!*, etc. (*ex* Max.). *Etorofu*, at Rubetsu.

Distrib. Kamtschatka, the Aleutian Islands, Sitka, and the Kuriles. As var. *japonica*, Max., in the higher mountains of Japan.

211. Pedicularis verticillata, L. Sp. p. 608; Bunge in Ledeb. Fl. Ross. III, p. 270; Max. Mél. Biol. X, p. 95, XI, p. 286, and XII, p. 891, t. 6, f. 123; A. Gray, Synop. Fl. II, p. 305.

Hab. *Urup!* (*ex* Max.).

Distrib. Arctic and alpine regions of Europe, Siberia, northern Tibet, Mongolia, northern China, northern Manchuria, Kamtschatka and its adjacent islands, the Aleutian Islands, and Alaska to the arctic regions.

212. Pedicularis amoena, Adams in Stev. Monog. p. 25, t. 7; Bunge in Ledeb. Fl. Ross. III, p. 271; Max. Mél. Biol. X, p. 97, XI, p. 286, and XII, p. 886, t. 5, f. 115.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Kamtschatka, eastern and northern Siberia to arctic Russia, and alpine regions of Dahuria, northern Mongolia, and of the Altai, Alatau and Baikal.

213. Pedicularis resupinata, L. Sp. p. 608; Bunge in Ledeb. Fl. Ross. III, p. 281; F. Schm. Fl. Sach. p. 163; A. Gray, Bot. Jap. p. 402; Max. Mél. Biol. X, p. 106, and XI, p. 831, t. 3, f. 51; Fr. & Sav. Enum. I, p. 351.

Hab. *Urup!* (*ex* Max.). *Etorofu*, at Shibetoro.

Distrib. Japan, Saghalin, Kamtschatka, throughout Siberia, Manchuria, northern China, Mongolia, and also in eastern Russia.

Var. **teucriifolia**, Max. Mél. Biol. x, p. 107; Herder, Pl. Radd. iv, 2, p. 91. *P. teucriifolia* M. a Bieb. in Stev. Monog. p. 31, t. 10, f. 1; Bunge, in Ledeb. Fl. Ross. iii, p. 282.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Kamtschatka and adjacent islands.

214. **Pedicularis euphrasioides**, Steph. in Willd. Sp. iii, p. 204; Bunge, in Ledeb. Fl. Ross. iii, p. 284; F. Schm. Fl. Sach. p. 163; A. Gray, Synop. Fl. ii, p. 307; Max. Mél. Biol. x, p. 112, and xii, p. 901.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Throughout northern and eastern Siberia, Dahuria, northern Manchuria, northern Saghalin, Kamtschatka and adjacent islands, Alaska and through arctic North America to Labrador and Greenland.

OROBANCHACEÆ.

215. **Boschniakia glabra**, C. A. Mey. *ex* Bong. Veg. Sitcha, p. 159; Ledeb. Fl. Ross. iii, p. 323; F. Schm. Fl. Sach. p. 164; A. Gray, Synop. Fl. ii, p. 313; Fr. & Sav. Enum. i, p. 354; Herder, Pl. Radd. vii, p. 7.

Hab. *Kurile Islands* (*ex* Pallas).

Distrib. Parasitic on the roots of *Alnus viridis* in eastern Siberia, in the Altai and Baikal; Dahuria, northern Manchuria, Saghalin, northern and middle Japan, Kamtschatka, the Aleutian Islands, Alaska, and to the Slave Lake district.

LABIATÆ.

216. **Scutellaria galericulata**, L. Sp. p. 599; A. Gray, Synop. Fl. ii, p. 381.— Var. **scordifolia**, Regel, Tent. Fl. Uss. p. 118; Herder, Pl. Radd. in Act. H. Petrop. x, 1, p. 28. *S. scordifolia*, Fisch.; Benth. in DC. Prodr. xii, p. 425; Ledeb. Fl. Ross. iii, p. 398; Fr. & Sav. Enum. i, p. 377.

Hab. *Shikotan*, in grassy places along the beach.

Distrib. Japan, Saghalin, Kamtschatka, eastern Siberia to the Altai district of Siberia, Manchuria, Corea, Mongolia and northern China.

The species is widely distributed in Europe, northern Asia and North America.

217. **Brunella vulgaris**, L. Sp. p. 600; Benth. in DC. Prodr. xii, p. 409; Ledeb. Fl. Ross. iii, p. 392; A. Gray, Synop. Fl. ii, p. 382; Fr. & Sav. Enum. i, p. 376.

Hab. *Etorofu*, at Furubetsu and Arimoi.

Distrib. Throughout the north temperate zone, mountains of Mexico, Australia and Tasmania.

218. **Galeopsis Tetrahit**, L. Sp. p. 579; Benth. in DC. Prodr. xii, p. 498; Ledeb. Fl. Ross. iii, p. 421; F. Schm. Fl. Sach. p. 165; A. Gray, Synop. Fl. ii, p. 385.

Hab. *Shikotan*, along small streams in the harbor, common. *Etorofu*, at Shana.

Distrib. Yezo, in Nemuro; Saghalin, Kamtschatka, Kodiak, Sitka, eastern Siberia, Manchuria, and to the Atlantic coasts of Europe. Naturalized in eastern North America from Europe.

219. **Stachys aspera**, Michx. Fl. Bor.-Am. II, p. 5; A. Gray, Synop. Fl. II, p. 387.—Var. **baicalensis**, Max. Fl. Asiæ Or. Frag. p. 44; Herd. Pl. Radd. in Act. H. Petrop. x, 1, p. 32. *S. Riederi*, Cham. in Linnæa VI, p. 570. *S. baikalensis*, Fisch. in Benth. Lab. p. 543; Fr. & Sav. Enum. I, p. 378 (in part). *S. palustris*, var. *hispida*, Ledeb. Fl. Ross. III, p. 414. *S. palustris*, var. *aspera*, f. *angustifolia!* A. Gray, Bot. Jap. 403.

Hab. *Shikotan*, in wet places.

Distrib. Yezo: Hakodate (J. Small), Sapporo, and common elsewhere; Saghalin, Kamtschatka, eastern Siberia along the Ochotsk coast to the Baikal district, and Manchuria. The species is widely distributed in the temperate regions of North America (west to New Mexico and Oregon), and in northeastern and eastern Asia under various forms.

I can hardly agree with Professor Maximowicz in considering some of the American forms of this species as identical with our present variety. Among the large number of specimens in the Gray Herbarium from different parts of the United States, I have failed to find any that agree even tolerably well with our Asiatic plant. Dr. Gray's var. *glabra* seems to approach nearest to var. *japonica*, Max., all characters considered.

PLANTAGINACEÆ.

220. **Plantago kamtschatica**, Link, Enum. H. Berol. I, p. 120; Ledeb. Fl. Ross. III, p. 478; F. Schm. Fl. Sach. p. 165; Herd. Pl. Radd. in Act. Hort. Petrop. x, 1, p. 62. *P. media*, A. Gray, Pl. Jap. p. 316.

Hab. *Etorofu*, common at Furubetsu, Shana and Shibetoro.

Distrib. Kamtschatka, Saghalin and Yezo.

P. asiatica, var. *vulgaris*, Turcz. Fl. Baic.-Dahur. II, fasc. 1, p. 11, is very closely related to our plant, and may be identical with it. Maack's Amur specimen, for instance, can scarcely be distinguished from *P. kamtschatica*, except by its leaves being occasionally 7-nerved and its spikes more elongated.

221. **Plantago major**, L. Sp. p. 112; Ledeb. Fl. Ross. III, p. 477; A. Gray, Synop. Fl. II, p. 389.—Var. **asiatica**, Desne. in DC. Prodr. XIII, 1, p. 695. *P. asiatica*, L. Sp. 113; Ledeb. Fl. Ross. III, p. 479; Fr. & Sav. Enum. I, p. 384, II, p. 469.

Hab. *Etorofu*, at Furubetsu and Shana.

Widely distributed in several forms throughout the continent of Asia, southern Europe and western North America. *P. major*, L., var. *Asiatica*, A. Gray, l. c., appears to be identical with *P. major*, var. (*P. japonica*, Fr. & Sav. Enum. I, p. 384, II, p. 469), the capsule in both cases being subglobose or broadly ovoid, and 10–12-seeded.

My Kurile plants, as well as those which are found commonly throughout Japan from Yezo to the Loochoo Islands, and which are generally recognized as *P. major*, L., var. *asiatica*, have only four or five seeds in each capsule. The seeds are greatly larger than in the typical *P. major*, and the capsules are more elongated and have a tendency to taper at the tip. Franchet suggests that our plant may be *P. Cornuti*, Gouan. (*P. paludosa*, Turcz.). *P. Cornuti*, however, has conspicuously winged seeds and blunt

ovoid capsules. Its leaves are elliptical, tapering gradually at both ends, and are generally shorter than the petioles.

Our plant may be a good geographical form of the widely spread *P. major*, L.

MONOCHLAMYDEÆ.

CHENOPODIACEÆ.

222. Chenopodium album, L.; Moquin in DC. Prodr. XIII, 2, p. 70; Fenzl in Ledeb. Fl. Ross. III, p. 697; Benth. Fl. Austr. V, p. 159; Fr. & Sav. Enum. I, p. 386.

Hab. *Shikotan*. *Etorofu*, at Tsurubetsu.

Very common in Asia and Europe, spreading over the other parts of the world.

223. Salsola Soda, L. Sp. p. 323; Moq. in DC. Prodr. XIII, 2, p. 189; Fenzl in Ledeb. Fl. Ross. III, p. 803; F. Schm. Fl. Sach. p. 167; Fr. & Sav. Enum. I, p. 388.

Hab. *Shikotan*. *Etorofu*, at Tsurubetsu.

Distrib. Southern Europe, northern Africa, desert regions of western and middle Asia, Saghalin, Japan and southwestern Manchuria.

POLYGONACEÆ.

224. Polygonum aviculare, L.; Meisn. in DC. Prodr. XIV, p. 97; Ledeb. Fl. Ross. III, p. 531; A. Gray, Pl. Jap. p. 317; Fr. & Sav. Enum. I, p. 394.

Hab. *Etorofu*, at Furubetsu and Shana.

Distrib. Native of Europe and temperate Asia, now naturalized in most parts of the world, especially in the temperate zones.

225. Polygonum viviparum, L. Sp. p. 516; Meisner in DC. Prodr. XIV, p. 124; Ledeb. Fl. Ross. III, p. 519; Cham. & Schlecht, in Linnæa, III, p. 38; Trautv. & Mey. Fl. Och. p. 75; Hook. f. Fl. Brit. Ind. V, p. 31.

Hab. *Kurile Islands* (*ex* Pallas). *Etorofu*, at Furubetsu, Nobori and Shibetoro.

Distrib. Arctic and alpine regions of Europe, Asia and North America. In Japan it extends southward to the alpine district of the main island; and in western North America to Utah, Colorado and Nevada.

226. Polygonum amphibium, L. Sp. p. 517; Meisner in DC. Prodr. XIV, p. 115; Ledeb. Fl. Ross. III, p. 520; Hook. Fl. Bor.-Am. II, p. 131; F. Schm. Fl. Sach. p. 168; Hook. f. Fl. Br. Ind. V, p. 34.

Hab. *Etorofu*, at Rausu.

Distrib. Europe, northern Asia, south to western Himalaya, Manchuria and the northern part of Yezo; northern North America to southern California, and along the Rocky Mountains to Mexico, and eastward in the Northern States; also in southern Africa.

227. Polygonum Weyrichii, F. Schm. in Max. Prim. Fl. Amur. p. 235, Fl. Sach. p. 169. —Var. **alpinum**, Max.! in Fr. & Sav. Enum. I, p. 402, and Mél. Biol. IX, p. 617. *P. polymorphum*, var. *lapathifolium*, F. Schm.? in Max. Prim. p. 234.

Hab. *Shikotan*, on the hillsides. *Etorofu*, at Shana and Shibetoro.

The Kurile plant coincides exactly with the Fuji specimen collected by Tschonoski, except in size. It is about two to three feet high, and the leaves are more distantly placed. *P. tripterocarpum*, A. Gray, in MS. [Ochotsk Sea (J. Small); Arakamtschetchene Island, Bering Straits (Wright); Plover Bay, eastern Siberia (Dall)], approaches our plant nearest in the characters of its flowers and fruit. The leaves are linear-lanceolate, short-petioled or subsessile, usually crowded two or three together at the nodes, smooth or sometimes slightly hairy on the veins beneath, ciliate and somewhat revolute at the margins; sheath entire; pilose, especially at the base. (See Rothrock, Fl. Alaska, p. 453.)

Distrib. Alpine districts of middle and northern Japan; Saghalin, and northeastern Manchuria? In Japan the typical form is found only in the volcanic districts.

228. **Rumex Acetosa**, L. Ledeb.; Fl. Ross. III, p. 510; Meisner in DC. Prodr. XIV, p. 64; Reg. & Til. Fl. Och. p. 74; Fr. & Sav. Enum. I, p. 395; Hook. f. Fl. Brit. Ind. V, p. 60.

Hab. *Etorofu*, at Tsuruhetsu and Shana.

Distrib. Europe, northern Asia, western Himalaya, Japan from Yezo to Loochoo, and Alaska.

229. **Rumex graminifolius**, Lamb. in Trans. Linn. Soc. X, p. 264, t. 10; Ledeb. Fl. Ross. III, p. 512; Meisner in DC. Prodr., XIV, p. 64. *R. Acetosella* var. *graminifolia*, Schrenk, Reise durch d. Tundr. d. Samoj. II, p. 519; Trautv. Pl. Sib. Bor. p. 99, and Fl. Ter. Tschuk. p. 32.

Hab. *Kurile Islands* (*ex* Pallas).

Distrib. Arctic Russia, northern Siberia to Tschuktches-land, Kamtschatka and adjacent islands.

URTICACEÆ.

230. **Ulmus campestris**, Sm. Eng. Bot. t. 1886; Planch. in Ann. Sc. Nat. ser. 3, X, p. 272, and DC. Prodr. XVII, p. 156; Trautv. in Max. Fl. Amur. p. 247; Max. Mél. Biol. IX, p. 22; F. Schm. Fl. Sach. p. 174; Fr. & Sav. Enum. 1, p. 431; Georgi, Beschr. d. Russ. R., III, 4, p. 828; Ledeb. Fl. Ross. III, p. 646.

Hab. "Auf der nächsten Kurilischen Insel" (*ex* Georgi).

Distrib. Middle and southern Europe, northern Africa, northern Asia to Manchuria, Saghalin and Japan.

231. **Urtica dioica**, L. Sp. p. 984; Ledeb. Fl. Ross. III, p. 637; Weddell in DC. Prodr. XVI, p. 50.—Var. **angustifolia**, Ledeb. Fl. Alt. VI, p. 240; Weddell, l. c., p. 52; Max. Mél. Biol. IX, p. 619; Fr. & Sav. Enum. I, p. 437.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Middle and southern Japan; Corea, northern China, Manchuria, eastern Siberia, Transbaikal, Dahuria, Altai Mountains to Russia. Also found in Mexico.

Var. **platyphylla**, Weddell, l. c., p. 51; Max. Mél. Biol. IX, p. 620. *U. platyphylla*, Wedd. Monog. p. 86. *U. dioica*, F. Schm. Fl. Sach. p. 174.

Hab. *Shikotan*, on hillsides. *Etorofu*, common around Furubura, Shibetoro, and other places.

Distrib. Very common in northern Japan; southern Saghalin and Kamtschatka.

CUPULIFERÆ.

232. **Betula alba**, L., subsp. **latifolia**, var. **Tauschii**, Regel! in Bull. Mosc. 1865, p. 399, t. 7, f. 11–14, and in DC. Prodr. XVI, p. 165; Fr. & Sav. Enum. I, p. 455.

Hab. Etorofu, at Shibetoro, and Arimoi.

Distrib. Middle and northern Japan, Manchuria and Siberia, at Nasimovo, and by Lake Baical.

233. **Betula Ermani**, Cham. in Linnæa, VI, p. 537, t. 6, f. D; Ledeb. Fl. Ross. III, p. 653; Trautv. & Mey. Fl. Och. p. 83; Reg. & Til. Fl. Ajan. p. 119; Trautv. in Max. Prim. Fl. Amur. p. 252; Regel, in DC. Prod. XVI, p. 176.—Var. **typica**, Reg. Bull. Mosc. 1865, p. 415; Max. Mél. Biol. XII, p. 923.

Hab. Etorofu, at Furubetsu and Nobori on the Arimoi side.

Distrib. Aleutian Islands, Kamtschatka, the Kurile Islands, and Yezo; Nemuro! and Saruru Sands!

The species is distributed in several forms in eastern Siberia, Kamtschatka and adjacent islands, Manchuria, Saghalin, and northern and middle Japan.

234. **Alnus viridis**, DC. Fl. Fr. III, p. 304.—Var. **sibirica**, Regel in Bull. Mosc. 1865, p. 422, and in DC. Prodr. XVI, p. 182; Fr. & Sav. Enum. I, p. 456. *Alnaster fruticosus*, Ledeb. Fl. Ross. III, p. 655; Trautv. & Mey. Fl. Och. p. 85; Trautv. in Max. Fl. Amur. p. 257; F. Schm. Fl. Sach. p. 175.

Hab. Kurile Islands (*ex* Pallas). *Etorofu*, at Nobori, on the Arimoi side.

Distrib. Alpine districts of Europe; Siberia from the Ural to Kamtschatka; Dahuria, Manchuria, Saghalin, northern and middle Japan, the Aleutian Islands, northern North America and Greenland.

235. **Alnus incana**, Willd. Sp. IV, p. 335.—Var. **hirsuta**, Spach, Rev. Bet. in Ann. Sc. Nat. ser. 2, XV, p. 207; Ledeb. Fl. Ross. III, p. 656; Reg. in Bull. Mosc. 1865, p. 434, and in DC. Prodr. XVI, p. 189; Trautv. in Max. Fl. Amur. p. 258; F. Schm. Fl. Sach. p. 175.

Hab. Shikotan, on hillsides. *Kurile Islands* (*ex* Georgi).

Distrib. Yezo, Saghalin, Kamtschatka, eastern Siberia, Manchuria and Dahuria.

The species is widely distributed in Europe, northern temperate Asia and North America.

236. **Quercus grosseserrata**, Blume, Ann. Mus. Lugd.-Bat. I, p. 306; DC. Prodr. XVI, p. 16. *Q. crispula*, var. *grosseserrata*, Miq. Ann. Mus. Lugd.-Bat. I, p. 104; Fr. & Sav. Enum. I, p. 446.

Hab. Etorofu, at Furubetsu and Nobori on the Arimoi side.

Distrib. Japan.

The absence of fruit in the original specimens very naturally led Miquel to unite this species with *Q. crispula*, for there is certainly a close resemblance in their leaves. The fruit of *Q. crispula* is, however, very different from that of *Q. grosseserrata*. In the former the cup is deeper, embracing about half the cylindric nut, falling off with it when ripe; while in the latter the cup is hemispherical, enclosing about one-third of the ovoid-oblong nut which falls off free when ripe.

An examination of a very large number of specimens from different parts of Japan, Manchuria and China, shows a great similarity between *Q. grosseserrata* and *Q. mongolica*, Fisch., of Saghalin and the main lands. There are slight differences in the characters of the cup-scales and of the foliage, but scarcely more than sufficient to make them merely varieties of one species.

SALICACEÆ.

237. Salix Caprea, L. Sp. p. 1020; Anders. in DC. Prodr. XVI, 2, p. 222; Ledeb. Fl. Ross. III, p. 609; Max. Fl. Amur. p. 243; F. Schm. Fl. Sach. p. 173; Reg. Tent. Fl. Uss. p. 131; Trautv. & Mey. Fl. Och. p. 78; Regel & Tiling, Fl. Ajan. p. 117.

Hab. *Shikotan*, on hillsides. *Etorofu*, at Furubetsu and Nobori.

Distrib. Europe, western Asia across the northern and central portions to eastern Siberia, Manchuria, Saghalin and northern Japan.

238. Salix stipularis, Sm. Fl. Brit. II, p. 1069; Ledeb. Fl. Ross. III, p. 605; Anders. in DC. Prodr. XVI, 2, p. 266; Turcz. Fl. Baic.-Dah. II, p. 107; Max. Prim. Fl. Amur. p. 243; F. Schm. Fl. Sach. p. 172.

Hab. *Etorofu*, between Arimoi and Shana.

Distrib. Europe; northern Asia to Manchuria, Saghalin and Yezo.

239. Populus tremula, L. Sp. p. 1034.—Var. **villosa**, Wesmael in DC. Prodr. XVI, 2, p. 325; Max. Fl. As.-Or. Frag. p. 49; Fr. & Sav. Enum. I, p. 463. *P. villosa*, Lange. in Reichb. Icon. XI, p. 30, t. 617, f. 1273.

Hab. *Etorofu*, near Tsurubetsu and at Shibetoro.

Distrib. Middle Europe; northern and middle Japan. The species is distributed over the greater part of temperate Europe, northern Africa, and northern Asia to Manchuria and Saghalin.

EMPETRACEÆ.

240. Empetrum nigrum, L. Sp. p. 1022; Ledeb. Fl. Ross. III, p. 555; DC. Prodr. XVI, 1, p. 25; Pallas, Fl. Ross. I, 2, p. 49; F. Schm. Fl. Sach. p. 171; Fr. & Sav. Enum. I, p. 429.

Hab. *Kurile Islands* (*ex* Pallas). *Shumshu* (J. Akakabe, and Hakodate Museum). *Etorofu*, at Shibetoro. *Kunajiri* (middle Nakamura).

Distrib. Arctic and alpine regions of the northern hemisphere; the Andes and antarctic America, extending to the islands of Tristan d'Acunha.

GYMNOSPERMÆ.

CONIFERÆ

241. Juniperus communis, L.; Pall. Fl. Ross. I, 2, p. 12, t. 54; Ledeb. Fl. Ross. III, p. 684; Carr. Conifér. p. 21; Parlat. in DC. Prodr. XVI, 2, p. 479; Max. Fl. Amur. p. 260; F. Schm. Fl. Sach. p. 178; Masters, Conifers of Japan, p. 497.

Hab. Kurile Islands (*ex* Pallas).

Distrib. Europe, western Himalaya, Siberia, Kamtschatka, Dahuria, Manchuria, Saghalin, British America to New Mexico and North Carolina.

242. **Taxus cuspidata**, Sieb. & Zucc. Fl. Jap. II, p. 61, t. 128; Miq. Prol. Fl. Jap. p. 333; Parlat. in DC. Prodr. XVI, 2, p 502; Fr. & Sav. Enum., I, p. 472; Masters, Con. Jap. p. 499. *Taxus baccata*, var. *microcarpa*, Trautv. in Max. Prim. Fl. Amur, p. 259; F. Schm. Fl. Sach. p. 175.

Hab. Etorofu, at Shibetoro. *Kurile Islands*, from *Ketoi*, the fifteenth island southward (*ex* Pallas, N. Nord. Beitr. IV, p. 128).

Distrib. Japan, Saghalin and Manchuria.

I can detect no differences between the Japanese plant and that of Saghalin and Manchuria in their characters of leaves and fruits. The ripened seeds in both cases are oval-orbicular, compressed, with two or rarely three ridges toward the apex, obtusely short-mucronate, chestnut-brown, and about 5 1-2 mm. long. *T. brevifolia*, Nutt., of western North America, is most closely related to our plant.

243. **Pinus parviflora**, Sieb. & Zucc. Fl. Jap. II, p. 27, t. 115; Parlat. in DC. Prodr. XVI, 2, p. 404; Fr. & Sav. Enum. I, p. 464; Engelm. Revision, p. 15, adnot. 2 (Bot. Works, p. 370); Masters, Con. Jap. p. 504.

Hab. Kurile Islands (*fide* Siebold).

Distrib. Middle and northern Japan; also in Nutka Island (*fide* Engelm.).

244. **Pinus pumila**, Regel in Regel, Rach und Herder, Pl. Pawl., no. 54; Glehn in Act. H. Petrop. IV, p. 87; F. Schm. Fl. Sach. p. 177. *P. Cembra*, var. *pumila*, Pall. Fl. Ross. I, 1, p. 4, t. 2, f. E–H; Ledeb. Fl. Ross. III, p. 674; Turcz. Fl. Baic.-Dah. II, p. 141; Parl. in DC. Prodr. XVI, 2, p. 403; Max. Prim. Fl. Amur. p. 262; Masters, Con. Jap. p. 505.

Hab. Kurile Islands (*ex* Pallas, etc.). Shumshu (Akakabe). *Etorofu*, at Furubetsu and Nabori.

Distrib. Northern and eastern Siberia, Dahuria, Manchuria, Saghalin, northern Japan, Kamtschatka, and arctic Alaska.

245. **Picea obovata**, Ledeb. Fl. Alt. IV, p. 210; Carr. Conif. p. 253; Max. Prim. Fl. Amur. p. 261; Regel, Tent. Fl. Uss. p. 136; Masters, Con. Jap. p. 506. *Pinus orientalis*, Ledeb. Fl. Ross. III, p. 671 (in part). *Pinus obovata*, Antoine, Conif. p. 96, t. 37, f. 2. *Pinus Abies*, Pall. Fl. Ross. I, 1, p. 6 (excl. synon.).

Hab. Kurile Islands? (*ex* Pallas).

Distrib. Northeastern Europe, from the Ural and Altai regions to eastern Siberia, Dahuria and Manchuria.

246. **Larix dahurica**, Turcz. in Bull. Mosc. 1838, p. 101; Carr. Conif. p. 270; Regel, Rev. Sp. Gen. Lar. p. 59, n. 6. *L. kamtschatica*, Carr. l. c., p. 279. *Pinus dahurica*, Fisch. in Endl. Conif. p. 126; Ledeb. Fl. Ross. III, p. 673.

Var. **japonica**, Max.! in Regel, l. c., p. 60; Gartenf. 1871, t. 685, f. 5.

Hab. Shikotan. Etorofu, at Furubetsu and Arimoi. Pallas mentions in his Neue Nordische Beiträge, IV, p. 133, that a larch occurs in Etorofu, growing only in the southern half of the island, and also in Kumashiri.

This variety seems to be restricted to the southern Kuriles and northeastern Yezo. The plant has been transplanted from Etorofu to the temple grounds of southern Yezo. Professor Maximowicz's original specimens are from a cultivated tree in Hakodate. The plant is distinct from *Larix japonica*, Murr. (*L. leptolepis*, var. *Murrayana*, Max.), which grows on Mt. Fuji.

The species is distributed through arctic and eastern Siberia, Dahuria, Manchuria, northern China, Saghalin, extreme northern Japan, and Kamtschatka.

MONOCOTYLEDONES.

ORCHIDACEÆ.

247. Microstylis monophyllos, Lindley, Gen. & Spec. Orchid. p. 19; Ledeb. Fl. Ross. IV, p. 50; Hook. Fl. Bor.-Am. II, p. 193; Gray, Man. 5th ed. p. 509; Turcz. Fl. Baic.-Dah. II, fasc. 1, p. 173; Regel & Tiling, Fl. Ajan. p. 121. *Ophrys monophyllos*, L. Sp. p. 947. *Malaxis monophyllos*, Swartz in Act. Bot. Stockh. 1800, p. 234; Franchet, Pl. Dav., p. 294. *Malaxis diphyllos*, Cham. in Linnæa, III, p. 34 (*fide* Turcz.). *Microstylis japonica*, Matsumura? in Cat. Pl. Herb. Univ. Tokyo, p. 189.

Hab. *Shikotan*, in exposed grassy places on top of cliffs. *Etorofu*, at Furubetsu.

Distrib. Northern and middle Europe; northern Asia, from the Ural and Altai regions to eastern Siberia, Dahuria and northern China; Yezo (Böhmer, 2-leaved form); Fuji-yama? (Yatabe); the Aleutian Islands; and British America to Ill. and Penn.

248. Liparis Schmidtii, Benth. in Journ. Linn. Soc. XVIII, p. 294, and in Benth. & Hook. Gen. Pl. III, p. 495. *Ephippianthus Schmidtii*, Reichb. f. in Regensb. Flora, 1868, p. 33, in F. Schm. Fl. Sach., t. 6, f. 1–7, and Xenia Orchid. II, p. 188, t. 180. *E. sachalinensis*, Reichb. f. in F. Schm. Fl. Sach. p. 180; Matsumura, Cat. Pl. Herb. Univ. Tokyo, p. 190.

Hab. *Etorofu*, in mossy places on Nobori, growing with *Linnæa borealis*.

Distrib. Southern Saghalin and the Kuriles, Yezo and alpine districts of middle Japan.

249. Orchis aristata, Fisch. ex Lindl. Orchid. p. 262; A. Gray, Bot. Jap. p. 409; F. Schm. Fl. Sach. p. 181. *O. latifolia*, var. *Beeringiana*, Cham. & Schlecht. in Linnæa, III, p. 26; Hook. & Arn. Beech. Voy. p. 117; Fr. & Sav. Enum. II, p. 29.

Hab. *Kurile Islands!* (*ex* Max.). *Etorofu*, at Rubetsu.

Distrib. Middle and northern Japan, southern Saghalin and Kamtschatka; the Aleutian Islands and Alaska.

250. Habenaria conopsea, Benth. in Benth. & Hook. Gen. Pl. III, p. 625; Hook. Stud. Fl. Brit. Isl. 3rd ed. p. 393. *Gymnadenia conopsea*, R. Br. in Hort. Kew. V, p. 191; Ledeb. Fl. Ross. IV, p. 64; Turcz. Fl. Baic-Dah. II, 1, p. 179; Lindl. Orchid. p. 275; F. Schm. Fl. Sach. p. 181; Reg. & Til. Fl. Ajan. p. 121; Franchet, Pl. Dav. p. 294.

Hab. *Shikotan*, on hillsides. *Etorofu*, at Rubetsu.

Distrib. In arctic and temperate Europe; western and northern Asia to eastern Siberia, northern China; Manchuria; Saghalin and northern Japan. As var. *ussuriensis*, in southern Manchuria and middle Japan.

251. Habenaria ussuriensis, Max. Mél. Biol. XII, p. 551 (under *Platanthera*). *P. tipuloides*, var. *ussuriensis*, Regel & Maack, Fl. Uss. p. 143, t. 10, f. 7–9; Fr. & Sav. Enum. II, p. 32.

Hab. Etorofu, at Furubetsu and Shibetoro.

Distrib. Southeastern Manchuria; Japan, from Kiusiu to northern Yezo and southern Kuriles.

My plant corresponds exactly with a specimen in the Gray Herbarium from Maximowicz, collected in northern Japan. The plant is much larger than that represented by Regel in his Tentamen Floræ Ussuriensis.

252. Habenaria (*Platanthera*) minor, Reichb. f. Orch. Jap. Symb. in Bot. Zeit. 1878, p. 75. *H. japonica*, var. *minor*, Miq. Prol. Fl. Jap. p. 139.

Hab. Etorofu, near Rubetsu in boggy places, growing with *Parnassia palustris*.

Miquel does not state the locality for his plant, but it may probably be somewhere in the alpine districts of middle or northern Japan. Tschonoski collected the same plant in Nambu. The flower of the Etorofu plant was greenish in color when collected. According to Reichenbach the plant is related to *Platanthera mandarina* and *P. tipuloides*.

IRIDEÆ.

253. Iris setosa, Pall. in Willd. herb.; Ledeb. Fl. Ross. IV, p. 96; A. Gray, Bot. Jap. p. 412; F. Schm. Fl. Sach. p. 184; Trautv. Pl. Sib. Bor. p. 114; Max. Mél. Biol. X, p. 713; Fr. & Sav. Enum. II, p. 42.

Hab. Kurile Islands! (ex Max.). *Shikotan. Etorofu*, at Rubetsu and Shibetoro.

Distrib. Eastern Siberia, Manchuria, Saghalin, Yezo, Kamtschatka, the Aleutian Islands and Alaska.

LILIACEÆ

254. Polygonatum officinale, All. Fl. Pedemont. I, p. 131; Ledeb. Fl. Ross. IV, p. 123; Baker, Journ. Linn. Soc. XIV, p. 554; Max. Mél. Biol. XI, p. 846.—Var. **Maximowiczii** Max. l. c. *P. Maximowiczii*, F. Schm. Fl. Sach. p. 185; Baker, l. c., p. 556. *P. sp. indeterm.*, Max. Fl. Amur. p. 275. *P. officinale*, var. *pluriflorum*, Miq. Prol. p. 312.

Hab. Etorofu, at Furubetsu.

Distrib. Japan, Saghalin, Manchuria and northern China.

The species is widely distributed in Europe and in temperate Asia.

255. Polygonatum humile, Fisch. in Max. Prim. Fl. Amur. p. 275; F. Schm. Fl. Sach. p. 185; Fr. & Sav. Enum., II, p. 55; Max. Mél. Biol. XI, p. 845. *P. officinale*, var. *humile*, Baker in Journ. Linn. Soc. XIV, p. 554.

Hab. Etorofu, at Rausu.

Distrib. Middle and northern Japan, Saghalin, Manchuria and Dahuria.

256. Streptopus amplexifolius, DC. Fl. Fr. III, p. 174; Kunth, Enum. IV, p. 205; Max. Fl. Amur. p. 273; F. Schm. Fl. Sach. p. 185; Fr. & Sav. Enum. II, p. 51; Watson, Proc. Am. Acad. XIV, p. 269.

Hab. *Etorofu*, near Tsurubetsu.

Distrib. Central Europe, northwestern China, Manchuria, Saghalin, northern and middle Japan, Kamtschatka; Alaska to northern California and New Mexico, across the north temperate region to the Atlantic coast, from Pennsylvania to Greenland.

257. **Maianthemum bifolium**, DC. Fl. Fr. III, p. 177; Kunth, Enum. V, p. 147; Baker, Journ. Linn. Soc. XIV, p. 562; Watson, Proc. Am. Acad. XIV, p. 246.—Var. **kamtschaticum**, Trautv. & Mey. Fl. Och. p. 92; F. Schm. Fl. Sach. p. 185; A. Gray, Bot. Jap. p. 414; Max. Fl. Amur. p. 276. *Smilacina bifolia*, Desf., var. *kamtschatica*, Gmel. Fl. Sib. I, p. 35; Ledeb. Fl. Ross. IV, p. 127; Fr. et Sav. II, p. 55.

Hab. *Etorofu*, at Furubetsu and Shibetoro.

Distrib. Manchuria, Saghalin, northern Japan, eastern Siberia, Kamtschatka, the Aleutian Islands, and from Alaska to California (var. *dilatatum*, Watson, l. c.).

258. **Convallaria majalis**, L. Sp. p. 314; Kunth, Enum. V, p. 131; Ledeb. Fl. Ross. IV, p. 126; Baker, l. c., p. 552; Watson, l. c., p. 242; Max. Fl. Amur. p. 276; Franchet, Pl. Dav. p. 303; F. Schm. Fl. Sach. p. 185; Fr. & Sav. Enum. II, p. 54. *C. Keiskei*, Miq. Prol. p. 312 (*ex* Baker).

Hab. *Etorofu*, at Rubetsu.

Distrib. Europe, northern Asia to Manchuria, northern China, Japan, Saghalin, and Corea. In North America, in the Alleghanies (Virginia to South Carolina).

259. **Hemerocallis Middendorffi**, Trautv. & Mey. Fl. Och. p. 94; Max. Prim. Fl. Amur. p. 285; Regel, Fl. Uss. p. 153; F. Schm. Fl. Sach. p. 187; Regel, Gartenf. 1866, p. 292, t. 522; Baker, Journ. Linn. Soc. XI, p. 359.

Hab. *Etorofu*, at Tsurubetsu, and Rubetsu.

Distrib. Eastern Siberia in the Ochotsk district, Manchuria, Saghalin and northern Japan.

260. **Allium Victorialis**, L. Sp. p. 295; Ledeb. Fl. Ross. IV, p. 184; Kunth, Enum. IV, p. 432; A. Gray, Bot. Jap. p. 416; Regel, Alliorum Monog. p. 170, and Allii Sp. Asiæ, pp. 294, 346; Fr. & Sav. Enum. II, p. 78.

Hab. *Etorofu*, at Rubetsu and Shibetoro.

Distrib. In alpine regions of southern and middle Europe; Siberia in the Ural, Altai, Baikal and eastern districts; Himalaya; western and northern China, Mongolia, Dahuria, Manchuria, Saghalin, middle and northern Japan, and Kamtschatka.

261. **Lilium cordifolium**, Thunb. in Linn. Trans. II, p. 332; Sieb. & Zucc. Fl. Jap. I, p. 33, tt. 13, 14; Miq. Ann. Mus. Lugd.-Bat. III, p. 157; Baker, Journ. Linn. Soc. XIV, p. 227; Fr. & Sav. Enum. II, p. 72; Bot. Mag. t. 6337; Elwes, Monog. Gen. Lilium, t. 1. *Hemerocallis cordata*, Thunb. Fl. Jap. p. 143. *Lilium Glehni*, F. Schm. Fl. Sach. p. 187.

Hab. *Kurile Islands* (*ex* Siebold).

Distrib. Saghalin, Japan, China.

262. **Lilium dahuricum**, Gawl. Bot. Mag. t. 1210; Kunth, Enum. IV. p. 264; Baker, Journ. Linn. Soc. XIV, p. 238; Elwes, Monog. Gen. Lil. t. 21; Fr. & Sav. Enum. p. 70. *L. spectabile*, Link, Enum. I, p. 321; Ledeb. Fl. Ross. IV, p. 151; Max. Fl. Amur. p. 280; F. Schm. Fl. Sach. p. 186; A. Gray, Bot. Jap. p. 415.

Hab. *Etorofu*, on the sandy beach near Rausu.

Distrib. Northern and eastern Siberia to the Baikal and Altai regions; Manchuria, Saghalin, northern Japan and Kamtschatka.

263. **Lilium avenaceum**, Fisch. ex Max. in Gartenf. 1865, p. 290, t. 485; F. Schm. Fl. Sach. p. 186; Baker, Journ. Linn. Soc. XIV, p. 245; Elwes, Monog. t. 35. *L. Martagon*, Led. Fl. Ross. IV, p. 149 (in part). *L. medeoloides*, Fr. & Sav. Enum. II, p. 63 (in part).

Hab. *Kurile Islands* (hb. Fisch. *ex* F. Schmidt). *Etorofu*, at Tsurubetsu, and Shibetoro.

Distrib. Middle and northern Japan, Kamtschatka, Saghalin, southeastern Manchuria.

264. **Fritillaria kamtschatcensis**, Gawl. in Bot. Mag. t. 1216; Ledeb. Fl. Ross. IV, p. 147: Trautv. & Mey. Fl. Och. p. 93; Hook. Fl. Bor.-Am. II, p. 181, t. 193, f. A.; Max. Fl. Amur. p. 279; F. Schm. Fl. Sach. p. 186; Baker, Journ. Linn. Soc. XIV, p. 273; Watson, Proc. Am. Acad. XIV, p. 259; Fr. & Sav. Enum. II, p. 62.

Hab. *Kurile Islands* (*ex* Pallas). *Etorofu*, near Tsurubetsu.

Distrib. Middle and northern Japan, Saghalin, Manchuria, eastern Siberia, Kamtschatka, the Aleutian Islands, and from Alaska to Vancouver Island.

265. **Disporum smilacinum**, A. Gray, Pl. Jap. p. 321, and Bot. Jap. 414; Miq. Prol. p. 311; Fr. & Sav. Enum. II, p. 52; Baker, Journ. Linn. Soc. XIV, p. 590; Max. Mél. Biol. XI, p. 858.

Hab. *Etorofu*, near Furubetsu.

Distrib. Japan, from the northern part of Yezo to Kinsiu. As var. *viridescens*, Max., in Manchuria and northern China.

266. **Clintonia udensis**, Trautv. & Mey. Fl. Och. p. 92, t. 30; Reg. & Til. Fl. Ajan. p. 123; Max. Fl. Amur. p. 278; F. Schm. Fl. Sach. p. 186; Fr. & Sav. Enum. II, p. 50; Baker, Journ. Linn. Soc. XIV, p. 584; Franchet, Pl. Dav. p. 309; Max. Fl. As. Or. Frag. p. 62.

Hab. *Etorofu*, on the Arimoi side of Nobori.

Distrib. Eastern Siberia in the Ochotsk district, Manchuria, Mongolia, northern China, Saghalin, and northern and middle Japan.

267. **Trillium kamtschaticum**, Pall. in Herb. Lambert, *ex* Pursh, Fl. Am. Sept. I, p. 246. *T. obovatum*, Pursh, etc. (excl. pl. Amer.); Ledeb. Fl. Ross. IV, p. 121; Max. Fl. Amur. p. 273, and Mél. Biol. XI, p. 861; F. Schm. Fl. Sach. p. 185. *T. erectum*, var. *album*, A. Gray, Pl. Jap. p. 320. *T. erectum*, var. *japonicum*, A. Gray, Bot. Jap. p. 413; Fr. & Sav. Enum. II, p. 56.

Hab. *Kurile Islands!* (*ex* Max.).

Distrib. Kamtschatka, Saghalin, eastern Manchuria and northern Japan.

Trillium obovatum of Pursh, which was described from specimens collected in Canada near Montreal, is a doubtful species and has never been verified from the same region. Dr. S. Watson thinks that the plant may be a form of *T. erectum*. According to the same authority *T. obovatum* of Hooker from British Columbia is *T. ovatum*, Pursh.

Our Asiatic plant, as fully characterized by Professor Maximowicz, differs distinctly

from the American *T. erectum*, *ovatum*, and *grandiflorum*, in its broader petals and shorter stigmas. The tip of the ovary is dark purple in color, and the petal is always white. *Trillium Tschonoskii*, Max., which grows also in Yezo, has the ovary greenish throughout. Its petals are white with a slight reddish tinge, and the anther is about as long as the filament. These two species have been much confused in Japan.

268. **Veratrum album**, L. Sp. p. 1044; Ledeb. Fl. Ross. IV, p. 208; Kunth, Enum. IV, p. 186; Turcz. Fl. Baic.-Dah. II, p. 229; Regel, Fl. Uss. p. 153; Baker, Journ. Linn. Soc. XVII, p. 470.

Hab. *Kurile Islands* (*ex* Turcz.).

The species is distributed through Europe and northern Asia to Kamtschatka and adjacent islands, and in Japan under different varieties and forms. According to Baker, as *V. Eschscholtzii* and *V. viride* in North America.

JUNCACEÆ.

269. **Juncus balticus**, Dethard; Willd. in Mag. d. n. f. Fr. in Berlin, 1809, p. 293; Kunth, Enum. III, p. 317; Ledeb. Fl. Ross. IV, p. 222; Engelm. N. Am. Juncus, p. 441; Trautv. & Mey. Fl. Och. p. 97; F. Schm. Fl. Sach. p. 189; Fr. & Sav. Enum. II, p. 533; Buchenau in Engler's Bot. Jahrb. VII, p. 161. *J. glaucus*, var. *yokoscensis*, Fr. & Sav. Enum. II, p. 97.

Hab. *Etorofu*, at Tsurubetsu.

Distrib. In the coast region of northern Europe to the arctic circle; in North America along the Atlantic coast from Newfoundland to Massachusetts, thence in the interior to Pennsylvania and across the lake regions to the Rocky Mountains and California and northwestward to Alaska, and the Aleutian Islands; eastern Siberia, Saghalin and northern and middle Japan.

270. **Juncus effusus**, L. Sp. p. 326; Thunb. Fl. Jap. p. 145; Engelm. N. Amer. Junc. p. 443; Watson, Bot. Calif. II, p. 206; A. Gray, Bot. Jap. p. 417; F. Schm. Fl. Sach. p. 189. *J. communis*, E. Mey. Synop. Junc. p. 12; Kunth, Enum. p. 320; Ledeb. Fl. Ross. IV, p. 221; Fr. & Sav. Enum. II, p. 97.

Hab. *Etorofu*, at Furubetsu.

Distrib. Widely spread in Europe, northern Africa, temperate Asia and America, New Zealand and Australia.

271. **Juncus articulatus**, L. Sp. p. 327; Ledeb. Fl. Ross. IV, p. 225; Engelm. N. Am. Junc. p. 458; Max. Fl. Amur. p. 293; Regel, Fl. Uss. p. 157; F. Schm. Fl. Sach. p. 189 (var.!). *J. lampocarpus*, Ehrh. Calam. no. 126; Buchenau in Engl. Bot. Jahrb. VII, p. 166.

Hab. *Etorofu*, at Arimoi.

My specimens agree exactly with the Saghalin plant collected by Schmidt. The cymes are terminal and suberect; flowers few in a cluster, also suberect. They agree well with Fries's *J. articulatus*, var. *subatratus*, which is placed under *J. lampocarpus*, Ehrh., by Buchenau. The species is very widely distributed through Europe, northern Africa, temperate Asia and eastern North America.

272. **Luzula pilosa**, Willd. Enum. I, p. 393; E. Mey. in Ledeb. Fl. Ross. IV, p. 214; Hook. Fl. Bor.-Am. II, p. 188; Turcz. Fl. Baic.-Dah. II, 1, p. 232; Miq. Prol. p. 329; Fr. & Sav. Enum. II, p. 96; Buchenan, l. c., p. 170.

Hab. *Etorofu*, at Furubetsu.

Distrib. Europe, northern Africa; temperate Asia and North America.

273. **Luzula campestris**, DC. Fl. Fr. III, p. 161; E. Mey. in Ledeb. Fl. Ross. IV, p. 219; Kunth, Enum. III, p. 307; Max. Prim. Fl. Amur. p. 292; F. Schm. Fl. Sach. p. 189; Fr. & Sav. Enum. II, p. 97.

Hab. *Etorofu*, at Furubetsu.

Distrib. Widely distributed over the temperate and colder regions of the globe.

Var. **congesta**, E. Mey. Synop. Luzul. p. 18; Linnæa, III, p. 376. *L. multiflora*, var. *congesta*, Koch, Synop. ed. 1, p. 734. *L. congesta*, Lej. Spa, p. 168. *L. campestris*, DC., var. *capitata*, Miq.! Prol. Fl. Jap. p. 329; Fr. & Sav. Enum. II, p. 97. *L. comosa*, var. *congesta*, Watson, Bot. Calif. II, p. 202.

Hab. *Shikotan*, on hillsides.

Our plant agrees in every respect with that from California; and it is also hardly distinguishable from the European specimens. It is often found in Japan, growing together with other forms of *L. campestris*. The plant seems to have as wide a range of distribution as the typical form. In North America, however, it is known only from the coast region of California to Alaska.

ARACEÆ.

274. **Lysichiton kamtschatcensis**, Schott, Gen. Aroid. t. 91, Prodr. p. 421; F. Schm. Fl. Sach. p. 178; Engl. in DC. Monog. II, p. 210; Fr. & Sav. Enum. II, p. 9. *Dracontium camtschatcense*, L. Sp. ed. 2, p. 1372. *Symplocarpus camtschaticus*, Salisb.; Bong. Veg. Sitch. p. 50; Hook. Fl. Bor.-Am. II, p. 169; Ledeb. Fl. Ross. IV, p. 12; Max. Fl. Amur. p. 266. *Arctiodracon japonicum*, A. Gray, Bot. Jap. p. 409; *Lysichiton japonicum*, Schott in Miq. Ann. Mus. Lugd. Bat. I, p. 96; Fr. & Sav. Enum. II, p. 9.

Hab. *Etorofu*, at Furubetsu.

Distrib. Middle and northern Japan; Saghalin; northeastern Manchuria; eastern Siberia to the Ochotsk Sea; Kamtschatka; Aleutian Islands; Alaska to California.

CYPERACEÆ.

275. **Carex microglochin**, Wahlbg. Act. Holm. 1803, n. 9; Ledeb. Fl. Ross. IV, p. 269; Turcz. Fl. Baic.-Dah. II, 1, p. 257; Boott in Hook. Fl. Bor.-Am. II, p. 210, and Ill. Car. IV, p. 174, t. 589; Bailey, Syn. N. Am. Car. p. 61.

Hab. *Kurile Islands* (*ex* Boott).

Distrib. Arctic and alpine Europe; Caucasus, Altai, Dahuria, Baikal, Thibet, western Himalaya; Colorado; Greenland.

276. **Carex rotundata**, Wahlbg. Act. Holm. 1803, n. 78; Ledeb. Fl. Ross. iv, p. 301; Kunth, Enum. ii, p. 451; Trautv. & Mey. Fl. Och. p. 99; Boott in Hook. Fl. Bor.-Am. ii, p. 220; Bailey, Syn. p. 67.

Hab. Kurile Islands! (*ex* Max.).

Distrib. Arctic and northern Europe; extreme eastern Siberia; arctic and northern North America; Greenland.

277. **Carex macilenta**, Fries, Summa Veg. p. 224; Anders. Cyp. Scand. p. 58, t. 4, f. 35; F. Schm. Fl. Sach. p. 193; Boott, Ill. iv, p. 147, t. 471.

Hab. Etorofu, at Shana.

Distrib. Lapland, Norway, Finland, Saghalin and the Kuriles.

278. **Carex Gmelini**, Hook. & Arn. in Beechey Voyage, p. 118, t. 27; Boott in Hook. Fl. Bor.-Am. ii, p. 216; Ledeb. Fl. Ross. iv, p. 288; Trautv. & Mey. Fl. Och. p. 99; Reg. & Til. Fl. Ajan. p. 125; Max. Fl. Amur. p. 309; F. Schm. Fl. Sach. p. 193; Boott, Ill. iv, p. 137, t. 440; Bailey, Syn. p. 77.

Hab. Etorofu, at Tsurubetsu.

Distrib. Northern Japan (Yezo); Saghalin; eastern Manchuria; eastern Siberia around the Ochotsk Sea; Kamtschatka; the Aleutian Islands; arctic Alaska to Oregon.

279. **Carex vaginata**, Tausch, in Regensburg Flora, 1821, p. 557; Kunth, Enum. ii, p. 451; Ledeb. Fl. Ross. iv, p. 291; Trautv. & Mey. Fl. Och. p. 99; Reg. & Til. Fl. Ajan. p. 125; Bailey, Syn. p. 117; Boott, Ill. iv, p. 148, t. 478. *C. falcata*, Turcz. Fl. Baic.-Dah. ii, 1, p. 276; Max. Fl. Amur. p. 311; F. Schm. Fl. Sach. p. 194.

Hab. Etorofu, at Tsurubetsu.

Distrib. Arctic and northern Europe; Siberia, from the Baical district to the Ochotsk region; Manchuria, Saghalin and the Kuriles; arctic America to the Rocky Mountains and New York.

280. **Carex macrocephala**, Willd. Spreng. Syst. iii, p. 808; Boott in Hook. Fl. Bor.-Am. ii, p. 215, t. 216; A. Gray, Pl. Jap. p. 328; Regel, Fl. Uss. p. 164, t. 12, f. 8–12; F. Schm. Fl. Sach. p. 193; Fr. & Sav. Enum. ii, p. 132; Boott, Ill. i, p. 27, t. 69; Bailey, Syn. p. 134.

Hab. Shikotan.

Distrib. Middle and northern Japan; Saghalin; Manchuria; Kamtschatka; north western coasts of America; Oregon and Washington Territory. It is also found in Corea.

281. **Carex transversa**, Boott in A. Gray, Pl. Jap. p. 324, and Ill. iv, p. 202; Miq. Prol. Fl. Jap. p. 357; Fr. & Sav. Enum. ii, p. 149.

Hab. Kurile Islands! (*ex* Max.).

Distrib. Middle and northern Japan.

282. **Carex rhynchophysa**, C. A. Mey. Ind. Hort. Petrop. ix, p. 10; Ledeb. Fl. Ross. iv, p. 318; Turcz. Fl. Baic.–Dah. ii, 1, p. 285; Trautv. & Mey. Fl. Och. p. 102; Max. Prim. Fl. Amur. p. 316; F. Schm. Fl. Sach. p. 197; Fr. & Sav. Enum. ii, p. 155.

Hab. Kurile Islands! (*ex* Max.).

Distrib. Northern and central Europe; throughout Siberia; Dahuria; Manchuria; Saghalin; middle and northern Japan.

GRAMINEÆ.

283. **Phalaris arundinacea**, L.; Trin. Phalar. p. 11; Hook. Fl. Bor.-Am. II, p. 234; Fr. & Sav. Enum. II, p. 157. *Digraphis arundinacea*, Trin. Fund. Agros. p. 127; Ledeb. Fl. Ross. IV, p. 454; Max. Fl. Amur. p. 326; F. Schm. Fl. Sach. p. 201.

Hab. *Etorofu*, at Tsurubetsu and Rubetsu.

Distrib. Widely distributed in the north temperate zone, extending to the Arctic region.

284. **Hierochloe borealis**, Rœm. & Schult. Syst. II, p. 513; Ledeb. Fl. Ross. IV, p. 407; Reg. & Til. Fl. Ajan. p. 126; Max. Fl. Amur. p. 322; F. Schm. Fl. Sach. p. 201; Fr. & Sav. Enum. II, p. 157.

Hab. *Etorofu*, at Rubetsu.

Distrib. Arctic, alpine and northern Europe, North America and Asia.

285. **Alopecurus geniculatus**, L., sub-sp. **fulvus**, Hook. f. Fl. of Brit. Isl. 3rd ed. p. 474. *A. fulvus*, Smith; Ledeb. Fl. Ross. IV, p. 464; F. Schm. Fl. Sach. p. 203; Franchet, Pl. Dav. p. 329. *A. geniculatus*, Thunb. Fl. Jap. p. 49; A. Gray, Pl. Jap. p. 328; Fr. & Sav. Enum. II, 158.

Hab. *Etorofu*, at Furubetsu.

The Japanese specimens in the Gray Herbarium, collected in different parts of the country (Nagasaki, Yokohama, Hakodate, Sapporo), are all referable to *A. fulvus*, Sm. They are all glaucous, and have inflated sheaths and yellow or orange-yellow anthers. The plant has been found in Saghalin, northern China, Hongkong, Himalaya, and Altai to Europe. Some of the specimens from northwest America can scarcely be distinguished from our plant.

286. **Agrostis canina**, L.; Trin. Agrostidea, p. 87; Ledeb. Fl. Ross. IV, p. 440; Reg. & Til. Fl. Ajan. p. 127; Max. Fl. Amur. p. 325; F. Schm. Fl. Sach. p. 201.

Hab. *Shikotan.* *Etorofu*, at Shara.

Distrib. Northern Japan, Saghalin, throughout northern Asia to Europe and Himalaya, northern and mountain districts of North America, South America, and Australasia.

287. **Agrostis perennans**, Tuckerm. in Sillim. Journ. 1843, p. 44; A. Gray, Manual, 5th ed. p. 611; Miq. Prol. Fl. Jap. p. 165; Fr. & Sav. Enum. II, p. 166. *A. Michauxii*, var. *clavata*, Trin. Uni- et Sesqui-f. p. 206; Bong. Veg. Sitcha, p. 170. *A. laxiflora*, F. Schm. Fl. Sach. p. 203. *A. scabra*, A. Gray, Pl. Jap. p. 328.

Hab. *Etorofu*, at Tsurubetsu and Nobori.

Our plant has flat leaves and greenish flowers, which are sometimes slightly tinged with a purplish color. The panicle is branched from about the middle, and is more or less scabrous, as also the keel of the glumes. The plant is just about intermediate in its general characters between *A. perennans* and *scabra*. A specimen from Saghalin, collected by F. Schmidt, coincides very closely with ours; so is also one named *A. Michauxii*, var. *clavata*, from Kamtschatka. The present form seems to occur also in northwestern America to Colorado (J. Wolf) and to the lake region.

288. **Deschampsia flexuosa**, Trin. in Mém. Ac. St.-Pét. 1836, p. 9; Ledeb. Fl. Ross. IV, p. 420; F. Schm. Fl. Sach. p. 202; Fr. & Sav. Enum. II, p. 172. *Aira flexuosa*, L.; Hook. Fl. Bor.-Am. p. 243; Trautv. & Mey. Fl. Och. p. 105.

Hab. *Etorofu*, at Shibetoro.

Distrib. Europe; western and northern Asia, northern and middle Japan, Saghalin, and the Ochotsk region; in North America, mostly on the Atlantic side, from Greenland to the northern Eastern States, and in Colorado; Falkland Islands.

289. **Phragmites communis**, Trin. Fund. Agr. p. 134; Turcz. Fl. Baic.-Dah. II, 1, p. 315; Fr. & Sav. Enum. II, p. 170. *Arundo Phragmites*, L.; Ledeb. Fl. Ross. IV, p. 393; Max. Prim. Fl. Amur. p. 321; F. Schm. Fl. Sach. p. 201.

Hab. *Shikotan.* *Etorofu*, at Tsurubetsu.

Distrib. Most widely distributed over the greater part of the globe.

290. **Melica nutans**, L.; Ledeb. Fl. Ross. IV, p. 399; Turcz. Fl. Baic.-Dah. II, p. 336; Max. Fl. Amur. p. 322; Reg. Fl. Uss. p. 169; F. Schm. Fl. Sach. p. 201; Fr. & Sav. Enum. II, p. 178.

Hab. *Shikotan.*

Distrib. Europe; northern Asia to Kamtschatka, Manchuria, Saghalin and Japan.

291. **Poa annua**, L.; Ledeb. Fl. Ross. IV, 377; Hook. Fl. Bor.-Am. II, p. 245; F. Schm. Fl. Sach. p. 200; Fr. & Sav. Enum. II, p. 174.

Hab. *Etorofu*, at Shana.

Distrib. Europe, northern Africa, temperate Asia. Naturalized in northern America, Australia, etc. A taller form of this species is apparently indigenous in Arizona, New Mexico, western Texas, etc. (Thurber).

292. **Poa pratensis**, L.; Ledeb. Fl. Ross. IV, p. 378; Reg. & Til. Fl. Ajan, p. 126; Max. Fl. Amur. p. 319; F. Schm. Fl. Sach. p. 200; Fr. & Sav. Enum. II, p. 174.

Hab. *Etorofu*, at Shibetoro.

Distrib. Widely spread in arctic and north temperate regions.

293. **Poa laxa**, Haenke; Thurber, Bot. Calif. II, p. 312; Ledeb. Fl. Ross. IV, p. 372; Hook. Fl. Bor.-Am. II, 246; Reg. & Til. Fl. Ajan. p. 126.

Hab. *Etorofu*, at Tsurubetsu.

Distrib. Arctic, alpine and northern Europe and North America; northern Asia in the Altai and Ochotsk regions of Siberia and in the Kuriles.

294. **Poa glumaris**, Trin. in Mém. Acad. Petersb. VI, 1, p. 379; Hook. Fl. Bor.-Am. II, p. 247; Max. Fl. Amur. p. 320; F. Schm. Fl. Sach. p. 200. *Glyceria glumaris*, Griseb. in Ledeb. Fl. Ross. IV, p. 392; Reg. & Til. Fl. Ajan. p. 126.

Hab. *Etorofu*, at Tsurubetsu.

Distrib. Northeastern coast of Yezo; Saghalin; northeastern Manchuria; eastern Siberia about the Ochotsk Sea; Kamtschatka; the Aleutian Islands, Alaska, and along the coasts of the Gulf of St. Lawrence.

295. **Glyceria festucaeformis**, Heynh.; Reichenb. Icon. Fl. Germ. I, p. 48, t. 152, f. 1613. *G. maritima*, Fries, var. *festucaeformis*, Max. Prim. Fl. Amur. p. 320; F. Schm. Fl. Sach. p. 200. *Atropis maritima*, Griseb. in Ledeb. Fl. Ross. IV, p. 391 (in part). *Poa festucaeformis*, Host, Gram. Austr. p. 3, t. 17; Hook. Fl. Bor.-Am. II, p. 245.

Hab. *Etorofu*, in the vicinity of Shana.

Distrib. In the littoral region of central Europe; in Manchuria, Saghalin, northern Yezo and northwestern America.

296. **Festuca ovina**, L.; Griseb. in Ledeb. Fl. Ross. IV, 350; Turcz. Fl. Baic.-Dah. II, 1, p. 339; Reg. & Til. Fl. Ajan. p. 125; Max. Fl. Amur. p. 318; F. Schm. Fl. Sach. p. 200; Fr. & Sav. Enum. II, p. 181.

Hab. Shikotan.

Distrib. Europe, northern Africa, northern Asia, Himalaya, Japan; North and South America; New Zealand and Australia.

The plant coincides very well with the descriptions of var. *violacea*, Gaud., as given by Grisebach and Maximowicz.

297. **Festuca rubra**, L.; Bong. Veg. Sitcha, p. 173; Hook. Fl. Bor.-Am. II, p. 250; Ledeb. Fl. Ross. IV, p. 352; F. Schm. Fl. Sach. p. 200; Miq. Prol. p. 170; Fr. & Sav. Enum. II, p. 181.

Hab. Etorofu, at Tsurubetsu.

Distrib. Arctic and northern temperate regions of Europe, Asia and North America.

298. **Elymus mollis**, Trin. in Spreng. Entd. II, p. 72; Bong. Veg. Sitcha, p. 174; Griseb. in Ledeb. Fl. Ross. IV, p. 332; Trautv. & Mey. Fl. Ochot. p. 102; Reg. & Til. Fl. Ajan. p. 125; Max. Prim. Fl. Amur. p. 317; F. Schm. Fl. Sach. p. 198. *E. arenarius* and *mollis*, Hook. Fl. Bor.-Am. II, p. 255. *E. arenarius*, Miq. Prol. p. 174.

Hab. Shikotan. Etorofu, in the vicinity of Shana.

The northeastern Asiatic and American plants have the glumes broad-lanceolate in shape, and short-acuminate, soft, silky-hairy on the back, with 3–5 (–7) prominent veins. The typical European *E. arenarius*, on the other hand, has a lanceolate long-acuminate setaceous glume, which is glabrous, except toward its tip; and the lateral veins are not so prominent as in the case of *E. mollis*. The character of the leaves is variable according to the nature of the locality and is not to be depended upon as a distinguishing character.

Distrib. Northern Japan; Saghalin; Manchuria; arctic and eastern Siberia; Kamtschatka; Alaska to Oregon, eastward across British America and the lake region to the Atlantic coast from northern New England to Greenland.

299. **Bambusa kurilensis.**—*Arundinaria kurilensis*, Rupr. in Bull. Petersb. VIII, p. 121; Steudel, Syn. Glum. p. 335; Ledeb. Fl. Ross. IV, p. 395; Munro, Monogr. Bamb. p. 17; F. Schm. Fl. Sach. p. 198 (var. *genuina*).

Hab. Urup! Etorofu, very common. According to Pallas this plant occurs on every island south of *Ketoi*.

While I was in Etorofu I searched carefully for the flowers and fruits of the bamboo so common in that island, but without any success. The original Kurile specimen, from which Ruprecht described very minutely its characters, was in fruit. The number of its stamens was not known to him. Under such circumstances, it was most natural for any one to place the plant under *Arundinaria*, as there is a remarkable resemblance between it and the plants of that genus.

Among my Yezo collection, I have two distinct *Bambusa*, one of which is *B. senanen-*

sis, Fr. & Sav., and the other, undoubtedly Ruprecht's species. In my specimens, which I consider to be identical with *A. kurilensis*, Rupr., the spikelets are generally in a simple raceme, oblong or obovate-oblong in outline, much flattened, 4–6 flowered, and 15–20 mm. in length; and they are appressed hairy and dull-ashy in color. The glumes are minute; the lower one is about 2 mm. long, and the upper about twice as long. The inferior palets are oval-oblong, acuminate, 8–12 mm. long; the superior is shorter and two-keeled. The stamens are six and included. The sheath of the leaves is not bearded at the throat. The branches and leaves are crowded and stunted in a fertile plant.

In the vicinity of Shana in Etorofu, the bamboo grows so thick and tall as to form almost impassable thickets. The different varieties (?) of *A. kurilensis*, Rupr., established by F. Schmidt, would most likely occur also in the Kurile Islands and in northern Japan and they require a most careful future study. Professor Maximowicz kindly informs me that the var. *spiculosa* of Schmidt has six stamens and is therefore a *Bambusa*. One of the original specimens of var. *paniculata*, F. Schm., in the Gray Herbarium, does not differ from *Bambusa senanensis*, Fr. & Sav.

CRYPTOGAMÆ.

LYCOPODIACEÆ

300. Lycopodium clavatum, L.; Thunb. Fl. Jap. p. 341; Max. Prim. Fl. Amur. p. 335; F. Schm. Fl. Sach. p. 204; Fr. & Sav. Enum. II, p. 197.

Hab. *Etorofu*, at Shibetoro.

Distrib. Arctic and in the cooler regions of the north and south temperate zones.

301. Lycopodium annotinum, L.; Ledeb. Fl. Ross. IV, p. 497; Trautv. & Mey. Fl. Och. p. 106; Max. Prim. Fl. Amur. p. 335; F. Schm. Fl. Sach. p. 204; Matsumura, Cat. Pl. Herb. Univ. Tokio, p. 240.

Hab. *Etorofu*, at Shibetoro, growing with *L. clavatum*.

Distrib. Northern and middle Japan, Saghalin, Manchuria, Siberia, Himalaya, Europe from the arctic to the southern alpine districts; and in North America, from New Jersey to Colorado and Washington, and northward to Greenland and arctic Alaska.

302. Lycopodium japonicum, Thunb. Fl. Jap. p. 341; Max. Mél. Biol. VIII, p. 341; Fr. & Sav. Enum. II, p. 197. *L. dendroideum*, Michx. Fl. Bor.-Am. II, p. 282; Milde, Fil. Europ. p. 253; Miq. Prol. Fl. Jap. p. 348; Ledeb. Fl. Ross. IV, p. 498; Trautv. & Mey. Fl. Och. p. 107; Reg. Fl. Uss. p. 174; F. Schm. Fl. Sach. p. 204.

Hab. *Etorofu*, at Furubetsu and Shibetoro. *Kumajiri* (middle Nakamura).

Distrib. Middle and northern Japan, Saghalin, Manchuria, eastern Siberia about the Ochotsk sea, Kamtschatka, the Aleutian Islands, and from Alaska across British America and the lake region to the mountains of North Carolina.

303. Lycopodium complanatum, L.; Ledeb. Fl. Ross. IV, p. 499; Trautv. & Mey. Fl. Och. p. 107; Max. Prim. Fl. Amur. p. 335; F. Schm. Fl. Sach. p. 204; Fr. & Sav. Enum. II, p. 198.

Hab. *Etorofu*, at Nobori and Shibetoro.

Distrib. Widely distributed over the temperate and colder regions of the northern hemisphere and the alpine districts in the tropics.

304. **Selaginella helvetica**, Link! Fil. Hort. Berol. (1841), p. 159; Baker, Journ. of Bot. 1883, p. 46; Ledeb. Fl. Ross. IV, p. 501; Max. Fl. Amur. p. 336; Franchet, Pl. Dav. p. 344; Fr. & Sav. Enum. II, p. 199.

Hab. *Shikotan*, on moist rocks.

Distrib. Alpine regions of central Europe, Caucasus and Persia, northern China, Manchuria and northern and middle Japan.

EQUISETACEÆ.

305. **Equisetum arvense**, L.; Ledeb. Fl. Ross. IV, p. 486; Max. Fl. Amur. p. 333; F. Schm. Fl. Sach. p. 204; Fr. & Sav. Enum. II, p. 202.

Hab. *Kurile Islands!* (Max.). *Shumshu* (Akakabe).

Distrib. Arctic and north temperate regions and also in the Himalaya.

306. **Equisetum limosum**, L.; Milde, Fil. Eur. p. 227; Ledeb. Fl. Ross. IV, p. 489; Turcz. Fl. Baic.-Dah. II, p. 356; Reg. & Til. Fl. Ajan. p. 127; Max. Fl. Amur. p. 334.

Hab. *Kurile Islands!* (Max.).

Distrib. Arctic and northern temperate regions of Europe, Asia (northern and middle Japan) and North America.

307. **Equisetum hyemale**, L.; Led. Fl. Ross. IV, p. 490; Max. Fl. Amur. p. 334; F. Schm. Fl. Sach. p. 204; Fr. & Sav. Enum. II, p. 203.

Hab. *Etorofu*, at Furnbetsu.

Distrib. Europe, northern Africa, northern and eastern Asia, and North America.

308. **Equisetum variegatum**, Schleich. Cat. Pl. Helv. (1807) p. 27; Ledeb. Fl. Ross. IV, p. 490; Ruprecht, Distrib. Crypt. Vasc. p. 26; Trautv. & Mey. Fl. Ochot. p. 106; Trautv. Fl. Terr. Tschuk. p. 40; F. Schm. Fl. Amg.-Bur. p. 73.

Hab. *Urup!* (Ruprecht).

Distrib. Europe, northern Africa, northern Asia and northern North America.

OPHIOGLOSSACEÆ.

309. **Botrychium Lunaria**, Swartz, Syn. Fil. p. 171; Rupr. Distrib. Crypt. Vasc. p. 33; Ledeb. Fl. Ross. IV, p. 504; Reg. & Til. Fl. Ajan. p. 128; Max. Fl. Amur. p. 336; F. Schm. Fl. Sach. p. 205.

Hab. First Island, Shumshu (Ruprecht). *Shikotan.*

Distrib. Europe, western and northern Asia, northern and middle Japan, Alaska and British America to Colorado and the northeastern States; also in Australia and Tasmania.

310. **Botrychium ternatum**, Swartz in Schrader's Journ. II, p. 111; Kunze, Pter. Jap. p. 491; Miq. Prol. Fl. Jap. p. 346; Fr. & Sav. Enum. II, p. 252; Milde, Fl. Eur. p. 199. *Osmunda ternata*, Thunb. Fl. Jap. p. 329, t. 32.

Hab. *Etorofu*, at Furubetsu.

Distrib. According to Milde, the plant is very widely distributed in various forms over northern and middle Europe; in North America from Newfoundland to Florida west to British Columbia and Mexico, the Aleutian Islands, Kamtschatka, Japan, the Sandwich Islands, Australia and New Zealand.

FILICES.

311. **Polypodium vulgare**, L.; Ledeb. Fl. Ross. IV, p. 508; Hook. & Baker, Syn. Fil. p. 334; A. Gray, Bot. Jap. p. 421; Max. Fl. Amur. p. 337; F. Schm. Fl. Sach. p. 205; Fr. & Sav. Enum. II, p. 244.

Hab. *Kurile Islands!* (Max.).

Distrib. Europe, northern and southern Africa, western and northern Asia, Manchuria, Saghalin, Japan and Kamtschatka; North America, from Sitka to New Mexico, eastward to New England and Canada.

312. **Woodsia polystichoides**, Eaton, Proc. Am. Acad. IV, p. 110; Miq. Prol. Fl. Jap. p. 343; Hook. & Baker, Syn. Fil. p. 48; F. Schm. Fl. Sach. p. 206; Fr. & Sav. Enum. II, p. 205; Franch. Pl. Dav. p. 347.

Hab. *Shikotan.*

Distrib. Japan, Saghalin, Manchuria, northern China and Mongolia.

313. **Aspidium fragrans**, Swartz, Syn. Fil. p. 51; Hook. Fl. Bor.-Am., II, p. 261; Trautv. & Mey. Fl. Och. p. 108. *Polystichum fragrans*, Ledeb. Fl. Ross., IV, p. 514; Max. Prim. Fl. Amur. p. 339; F. Schm. Fl. Sach. p. 206.

Hab. *Shikotan.*

Distrib. Throughout Siberia; Dahuria, Manchuria, Saghalin, Yezo, Kamtschatka to Alaska; arctic America to Iceland, and south to New England and Wisconsin.

314. **Cystopteris fragilis**, Bernh.; Rupr. Distrib. Crypt. Vasc. p. 39; Ledeb. Fl. Ross. IV, p. 516; Trautv. & Mey. Fl. Och. p. 108; Hook. Fl. Bor.-Am. II, p. 260; Max. Fl. Amur. p. 339; Reg. Fl. Uss. p. 177; F. Schm. Fl. Sach. p. 206; Franch. Pl. Dav. p. 347.

Hab. *Kurile Islands* (Rupr.).

Distrib. Arctic and northern and southern temperate regions; also in the mountains of the tropics. In Japan, so far as I am aware, Abashiri and Notoro Sands in northern Yezo seem to be the only localities for the plant, where I collected it in 1884.

315. **Asplenium Filix-foemina**, Bernh.; Ledeb. Fl. Ross. IV, p. 518; Hook. & Baker, Syn. Fil. p. 227; Max. Fl. Amur. p. 341; F. Schm. Fl. Sach. p. 206; Fr. & Sav. Enum. II, p. 226.

Hab. *Shikotan.*

Distrib. Widely distributed through Europe, Africa, Asia, and North and South America.

316. **Asplenium spinulosum**, Baker; Hook. & Baker, Syn. Fil. p. 225; Miq. Prol. Fl. Jap. p. 338; Fr. & Sav. Enum. II, p. 222. *Cystopteris spinulosa*, Max. Fl. Amur. p. 340. *Athyrium Hookerianum*, Moore, Ind. Fil. p. 185; Milde, Fil. Eur. p. 57 (in part); F. Schm. Fl. Sach. p. 206. *Asplenium subtriangulare*, Hook; Hook & Baker, l. c.

Hab. *Etorofu*, at Furubetsu and Shibetoro.

Distrib. Japan, Saghalin, Manchuria, Corea, China and the Himalaya.

317. **Pteris aquilina**, L.; Thunb. Fl. Jap. p. 332; F. Schm. Fl. Sach. p. 206; Fr. & Sav. Enum. II, p. 215.

Hab. *Etorofu*, at Furubetsu.

Distrib. Widely spread over a great part of the world.

VIII. Phylogeny of the Pelecypoda.

The Aviculidæ and their allies.

By Robert Tracy Jackson, S.D.

CONTENTS.

I. Introduction . . . . . p. 277
II. Sources of material and methods of work . . . . . p. 284
III. Classification of stages of growth and decline . . . . . p. 288
IV. Ostrea: development of the soft parts; embryology . . . . . p. 294
V. Ostrea: development of the soft parts; the spat . . . . . p. 303
VI. Ostrea: development of the shell p. 311
VII. Gryphæa, Exogyra and adult Ostrea, with a consideration of the mechanical origin of the ostrean form of shell p. 317
VIII. Perna, Avicula and near allies . p. 327
IX. Pecten: anatomy and habits . p. 333
X. Pecten: the shell . . . p. 342
XI. Genera allied to Pecten . . p. 350
XII. Anomia: anatomy and habits . p. 354
XIII. Anomia: the shell . . . p. 359
XIV. Studies of a few other genera . p. 362
XV. On the genetic relations of the Prodissoeonch . . . . p. 375
XVI. Genealogical connection of the Aviculidæ and their allies . p. 379
XVII. List of papers quoted or referred to in the text . . . p. 394
XVIII. Description of plates. . . p. 395

I. Introduction.

My palæontological studies have been carried on at the Museum of Comparative Zoology as a pupil and assistant, first of Professor Nathaniel S. Shaler and later of Professor Alpheus Hyatt. To these gentlemen first are due my acknowledgments in this paper, which was offered as a thesis for the degree of Doctor of Science at Harvard University May 1, 1889.[1] Acknowledgments are next due to Mr. Alexander Agassiz for the opportunity to study the collections in the Museum.

The investigations on which this paper is based were made while associated with Professor Hyatt in the Palæontological Department of the Museum.[2] I have applied some of the principles which he has deduced as a result of his scientific work, but I wish to state that he has never urged his views upon me, or pointed out their application in the Pelecypods. At Professor Hyatt's special request, I have used entire freedom in rejecting or criticising his views whenever they seemed not in accordance with the facts presented.

[1] On account of new material obtained, some additions have been made to this paper since it was read before the Society on April 3, and since it was offered as a thesis on May 1, 1889. The additions for the most part have been made to sections VIII and XIV, and are indicated by the date of the collecting of the material.

[2] Three years have been spent in that department assisting Professor Hyatt arranging the great collections of Fossil Invertebrates.

For the freest opportunity to study collections under their charge and for frequent assistance while studying those collections my obligations are due to Dr. C. A. White and Dr. William H. Dall of Washington; Professor Angelo Heilprin of Philadelphia; Professor R. P. Whitfield of New York; Dr. J. Walter Fewkes and Mr. Samuel Henshaw. For material borrowed for study, I am indebted to Dr. White, Dr. Dall, the Museum of Comparative Zoölogy, the State Museum of New York and the Boston Society of Natural History. I have to thank Colonel Macdonald, United States Commissioner of Fisheries, for the electrotypes of figures of *Ostrea edulis* and Professor A. E. Verrill for electrotypes of Vermetus, Pecten and Anomia.

In order to unravel with any reasonable hope of success the relationships of the multitude of fossil forms of animal life in which only the hard parts are commonly preserved, and to demonstrate the connection between the living and fossil representatives of allied groups, it is most important to study with minute care the hard parts in living genera. It is necessary to know as far as possible the structure, development and functional expression of the hard parts, both by themselves and in their relation to the soft parts. To attain this end, studies of any given animal should be made on all stages of growth from the embryonic upward, and in so far as the young is considered as a living expression of the adults of ancestral groups, this period of the life-history must be studied with special care.

On the value of anatomy and embryology to the palæontologist studying the affinities of groups I would quote the following passage from Professor Huxley's Anatomy of Invertebrated Animals, p. 587. "Already indications are not wanting that the vast multitude of fossil Arthropods, Mollusks, Echinoderms and Zoöphytes, now known, will yield satisfactory evidence of the filiation of successive forms, when the investigations of palæontologists are not merely actuated by the desire to discover time-marks and to multiply species, but are guided by that perception of the importance of morphological facts which can only be conferred by a large and thorough acquaintance with anatomy and embryology. But, under this aspect, the palæontology of the *Invertebrata* has yet to be created."

The results of my investigations give abundant proofs that a study of the soft parts and especially studies of life habits and environing influences will throw light on the meaning of the form of hard parts. They all lead toward the conclusion that external hard parts are built conforming to the needs of the animal and are modified by circumstances of environment. Many facts discussed in this paper are directly opposed to the assumption that hard parts are of prescribed form, to which the animal adapts itself, as I have found most active response in the form of hard parts to changed or changing conditions of the anatomy or habits of the animal. The changes in form thus introduced might well be called cases of "mechanical genesis," adopting Professor Ryder's apt phrase used of the development of toothed forms in Vertebrates.[1] When the meaning of features of shell form in living animals is ascertained, it is recognized that they make important factors in the consideration of fossils and the serial connection of groups.

To unite living and fossil forms of a group of Pelecypoda in a common study is the

[1] Facts bearing on this point are especially considered in the origin of the ostrean form of shell (section VII), and in the discussion of Perna (section VIII), Pecten (sections IX and X), and Anomia (section XII).

aim of this paper. It is hoped by this means to make connections and differences existing between some genera better understood, and thus to further the knowledge of the relationships of those genera. So much time has been given to the study of living forms that fossils do not figure as largely as they should in a paper of this nature. It is hoped, however, that in future this want may be supplied by investigations in that direction.

The main line of my research is the *study of shell structure and form.* Studies of anatomy and habits are subservient and correlative to those of the shell. Facts observed that have no bearing on shell structure are however frequently given as they may yet be of interest or of serial value. In studying the shell I have sought especially for young shells hoping in them to find characters of interest which would be valuable in attempting to trace the genetic connection of groups. It is to this study of the young, that Professor Hyatt has especially devoted himself in his researches among the Cephalopods, and I owe a debt of gratitude to him for the suggestion to try the same method of research in Pelecypods, as well as for the encouragement and sympathy he has given me in my work.

The young shell of Pelecypods has been very little studied either by itself or in its relation to later stages, and I know of no studies embracing observations on the development of the shell in related genera, or any attempt to trace the connections between the changes of shell form and anatomy during the development of the individual. In Zittel's Palæontology (Barrois' translation) we find in the consideration of the Pelecypoda the following statement: "Quant aux modifications des coquilles à leurs différentes âges, elles n'ont été que bien peu étudiées jusqu' ici, et ces observations n'ont pas encore mises à profit dans la systématique." The researches of this paper may therefore be considered as opening up a new field of investigations, as I consider not only the changes in form and structure observed at different periods of development in several genera, but also trace in many cases the serial connection between those changes in form and the phylogenetic history of the group.

Pelecypods are commonly divided into three groups accordingly as the adults possess a single adductor muscle, Monomyarians; two equally developed adductor muscles, Dimyarians; or two adductor muscles, one large and functionally the most active, the other smaller, Heteromyarians. This classification, I believe, is misleading, as by it are grouped together genera having no close relation and similarly genera closely akin are separated. I show that the size and number of the adductors are closely connected with the relative position of the axes of the body to the hinge axis (section v), and refer to the fact that the single adductor condition is adopted by several genera not related and which it would be entirely disregarding the sense of systematic classification to group together. On this basis of adductor muscle classification even different species of one genus would in one case have to be placed in the Heteromyarians and in another in the Monomyarians (see Mytilus, section v, note). The words monomyarian, etc., are occasionally used in the text, but as general descriptive terms, not with the classificatory value ordinarily applied to them.

In the text frequent reference is made to the law of concentration and acceleration of

development. This law was enunciated separately and almost simultaneously by Professors Hyatt (29)[1] and Cope. The law is, *that characteristics acquired in the adult, if inherited at all, are inherited at earlier and earlier periods in successive generations, until they exist only in embryonic stages, or are completely lost through disuse and concentration and acceleration of development.* This law finds strong support in the facts presented in the development of the oyster and other Pelecypods as well, where many peculiarities occur which are well explained by it. A corollary of the law of concentration and acceleration of development is that, *in the young stages are found the equivalents of which are to be sought in the adults of related groups.*

I have met with difficulty in procuring young specimens of Pelecypods to study, for the most part depending on what I collected in the field or found adhering to masses of shells in the museums. Conchologists commonly pay little attention to the young in their collections as they are not considered characteristic. They certainly are not characteristic, in that they have not a full expression of features found in the adult, but they are characteristic of their period in the development of the individual and from this point of view they are well worth collecting and studying carefully.

In section III Professor Hyatt's classification of stages of growth and decline is considered in its application to mollusca. I have there qualified some of his definitions and introduced a new term, *phylembryo*, which is applied to the stage in development where features exist which first render the embryo referable to the class or phylum to which it properly belongs. In considering stages of growth it is a valuable assistance to have an established nomenclature by which any given period may be briefly and definitely expressed, and that given in this paper seems to fill the requirements of such a nomenclature.

The phylembryonic stage of developing Pelecypoda presents some striking features which have not been previously considered as far as known. The shell of this period is characterized by having a straight hinge line as shown in many genera (fig. 25, p. 300, Pl. XXIII, figs. 7–11 and Pl. XXIV, figs. 13–15), although later succeeded by a curved one. An important point is the fact that at this age but one adductor muscle exists, and that one is destined to become the anterior adductor of adults which retain it (dimyarians). The posterior adductor is developed later. The mouth and anus in early embryonic stages of Pelecypods are closely related on the ventral border of the embryo (fig. 23, p. 299) and the anterior adductor muscle develops early on the dorsal side of the alimentary canal (fig. 25, p. 300; Pl. XXIII, figs. 9–11) which position it retains throughout life, in dimyarians. The posterior adductor is not developed until the anus has revolved dorsally from its early ventral position, and then the adductor is formed on the ventral side of the alimentary canal, which position it retains throughout life in all Pelecypods. We see, therefore, in this an explanation of the relation of the adductor muscles to the alimentary canal, one adductor overlying, the other underlying it, Pl. XXV, figs. 9–12 (for full discussion see section V).

[1] A list of publications quoted or otherwise referred to is given in section XVII. Where the reference in the text is not perfectly evident, a number in brackets is used which as in this case corresponds with a number on the reference list.

One of the most important discoveries described in this paper is the existence in young Pelecypods of an *embryonic shell, or prodissoconch comparable to the embryonic shell or protoconch of cephalous molluscs.* The shell of Pelecypods develops from a preconchylian gland, as does the shell of cephalous molluses; therefore, the two valves of a Pelecypod are together homologous with the single valve of univalves as was shown by Brooks (7). The adult shell of cephalous molluses has been named the conch, or true shell, and the first formed embryonic shell on account of its differences the protoconch; as the adult double shell of Pelecypods is the homologue of the adult single shell of univalves I have named it the *dissoconch* (double shell); similarly the early embryonic double shell on account of its differences I named the *prodissoconch* (early double shell). A prodissoconch is described in this paper in twenty-four genera of Pelecypods,[1] figures of most of which are given in the plates. It has been found in many species of some genera. These genera are widely separated so that it may be considered as proven that a prodissoconch is a characteristic feature of developing Pelecypod shells (discussion and descriptions, sections VI to XV inclusive).

In the discussion of the prodissoconch it will be seen that stress is laid on the direction of the umbos, as to whether they are inclined anteriorly or posteriorly relatively to the anatomy of the animal at the close of the prodissoconch period. I find that they are inclined posteriorly in Avicula, Perna, Ostrea, Pecten, Spondylus, Plicatula and Anomia. On the contrary they are inclined anteriorly in the other genera described except the Unionidæ. The value of this feature may be overrated, but I think it is of importance in considering the connection of genera and the derivation of the prodissoconch (section XV).

In considering what value is to be attached to inclination of the umbos, attention should be called to two singular, ancient palæozoic genera, Antipleura and Dualina, described by M. Barrande. In single species of these genera series of specimens may be picked out in which the umbos are inclined in one direction, and other series may be picked out in which the umbos are inclined in the opposite direction; the two series being apparently identical in every other character. This is a puzzling case, seemingly opposed to all natural laws. M. Barrande figures large numbers of specimens illustrating the two series, and I have studied them in the Schary collection of fossils from Bohemia, now in the Museum of Comparative Zoölogy). Ordinarily, however, the inclination of the umbos is a constant character and therefore I think it is not a mistake to consider it a feature of serial value as I have done in the text.

The prodissoconch of Ostrea, Perna, Pecten, Anomia and allies, is composed of homogeneous sub-nacreous lime showing no prismatic cellular layer, fig. 27, section VI, the first stages of the dissoconch growth on the other hand in these genera possesses a prismatic cellular structure making a marked contrast in histological structure with the

[1]Previous to the publication of my preliminary paper, an early embryonic shell and its relations to the succeeding shell had been described at some length by Ryder in the oyster, briefly by Morse in Anomia, and briefly by Lacaze-Duthiers in Mytilus. With these exceptions I believe my descriptions are the first concerning the early embryonic, prodissoconch shell and its relation to the succeeding dissoconch shell in Pelecypods. In this paper a prodissoconch is described in the following genera: Ostrea, several species; Gryphæa; Exogyra; Perna; Avicula; Pecten, several species; Spondylus; Plicatula; Lima; Anomia, two species; Mytilus; Modiola, Crenella; Argina; Unio; Margaritana; Anodon; Sphærium; Petricola; Scrobicularia; Venus; Tottenia; Mya and Saxicava.

condition in the prodissoconch. In Mya, Modiola, Venus and most other genera studied (section XIV) no prismatic layer was observed in the first stages of dissoconch growth and this difference, with others considered, is deemed sufficient to separate widely these two divisions of genera.

A discovery of much importance is the existence of *two adductor muscles in the prodissoconch stage of Ostrea*, Pl. XXIV, figs. 1–2. From the form of the shell and from analogy, a similar condition is predicated in Pecten, Avicula, Perna, Anomia, etc. All these genera possess but one adductor muscle in the adult and it has not been demonstrated before (excepting in Ostrea in my preliminary paper) that two exist in the young. Professor Huxley in 1883 showed that the first formed muscle of the oyster (fig. 25, p. 300, this paper) could not be that of the adult and that a new, second muscle to be retained throughout life must develop. On this basis and knowledge of early types of Pelecypods, he argued that Ostrea must have developed from a dimyarian ancestry and my discovery of the early two-muscled stage, therefore proves the truth of his assumption (discussion, sections IV and XV, also briefly in other sections on Perna, Pecten, etc.).

There is commonly little consideration given to the true relations of the axes of the body to the shell in describing Pelecypods. In dimyarians the hinge is dorsal and in monomyarians the hinge area is also considered as dorsal almost universally. Professors Hyatt (28), Brooks (9), Ryder (60) and Lacaze-Duthiers (39), have pointed out the true condition of affairs in Ostrea and Anomia, where on account of the changed position of the axes of the body the hinge line is anterior, not dorsal. I have endeavored to maintain this more careful consideration of the true relation of parts in my paper and this must be borne in mind in reading the text. For instance, in Pecten the hinge line being anterior, the free ends of the valves are posterior and the ears are truly ventral and dorsal, not anterior and posterior as usually described. This changed position of the axes is intimately connected with the relative size of the adductor muscles of the valves; a change in position coinciding serially with the decrease and final loss of the anterior adductor, together with the increase and final exclusive retention of the posterior adductor, as described in section V.

The Ostreadæ is a group having a peculiarly modified highly irregular shell which has been a perplexing problem to naturalists in seeking the affinities of the group. As the result of my studies I have come to the conclusion that the *ostrean form of the shell is due to the mechanical conditions of direct cemented fixation.* The proof of the conclusion is that all Pelecypods which are directly attached by the cementation of one valve assume a similar form of growth. The form claimed as the result of cementation of one valve is a concave, highly modified, attached valve and a less modified, commonly much flatter free valve, often differing so widely from the attached valve, as not to be recognizable as belonging to the same species unless found in place. Cementation also apparently induces a camerated structure of the shell. (See Pl. XXV, fig. 8 and Pl. XXVI, figs. 1–15, as proof of the effects of cemented fixation.) *This statement contains important conclusions*, which are discussed in the text (sections VII and XI) but they may be briefly stated here. The normal Pelecypod is bilaterally equivalvular, but when attached this feature is lost, asymmetry replacing the typical condition. The cemented valve is highly modified, the free valve less markedly so; therefore it is the free valve

which retains more of the ancestral features, and to it and the free young, before modifying cementation takes place, we must turn in studying the relationships of attached Pelecypods. It is an animal with one side modified, losing ancestral features; the other side, less modified, therefore retaining ancestral features. The actual change from an unmodified free form to a modified cemented form may be studied in Ostrea (Pls. XXIV, XXV), Hinnites and Mulleria (Pl. XXVI, figs. 3–7) and Spondylus (Pl. XXVII, fig. 4). The irregularity of attached shells being due to the condition of fixation we may study their relationships with an entirely new light on the subject, as the irregularity is a character superimposed on any regular form of Pelecypod by special given conditions. The aberrant forms of the Chamidæ and their greatly specialized allies the Rudistæ (Pl. XXVI, figs. 8–12 and 20) are considered as extremes of modification in the ostrean line of variation. What the mechanical causes of this line of variations probably are, and what they lead to as their highest expression is considered in section VII.

Finding that irregularity commences with the introduction of the fixed period we have a powerful argument in explaining the absence of features in the young dissoconch stages of Ostrea which might, if free, have retained the form of related ancestral groups, as is the case in the young of Perna, Pecten, Spondylus, etc. Ostrea is cemented at the close of prodissoconch period so that stages of shell growth later than that are all modified. The free valve should retain more ancestral features than the attached valve and this is the case with the oyster. The prodissoconch, the free valve and anatomy of the adult, all unite in characters which refer the Ostreadæ to a type, which is Perna, or some close ally of that genus (sections V–VII).

I have described the development of the gills of the oyster with some care, as it is but slightly treated of by other investigators of this mollusc. In order to understand the serial development of the several lamellæ and to show the relations of the direct and reflected borders of the filaments, diagrams are given (Pl. XXIV, figs. 6–12) of the development of the gills of Ostrea, together with diagrams of adult gills in some related genera.

In Perna (Pl. XXVII, figs. 1–3) I find a prodissoconch very closely like that of Ostrea; but the initial stages of dissoconch growth show indications of a byssal notch not seen at all in the prodissoconch. This character of a byssal notch originating in the initial stages of dissoconch growth, but not seen in the prodissoconch, is described also in Avicula, Pecten and Spondylus (Pls. XXVII–XXVIII, sections VIII–XI).

In Pecten, interesting facts are presented in regard to the life habits of crawling, byssal attachment and mode of swimming, new points are discussed and the shell is described at length in the young of five species. In all these young I found a prodissoconch with important characters. The first stages of dissoconch growth in four species were found to possess well defined prismatic structure in the right valve whereas this is not known in the adults of these species, and in the extensive researches of Professor Carpenter on shell structure, prismatic tissue was found in only one species of Pecten. The Pectens are allied to a group of Pelecypoda which has prismatic structure, in the shell, and it is a highly interesting fact in accord with other conclusions, that in the extreme young this feature exists, though early lost and not seen at all in adults. In the young dissoconch stages of Pecten (Pl. XXVIII) in many species I find characters in the form of the

shell which are referable in the closest manner to ancestral groups in early geologic times, from which the Pectens were doubtless evolved. The life-history of Pecten shows most strikingly how the phylogenetic history of a group may be traced by the series of stages presented in the early development of the individual (sections IX–X).

Studies were made of young Anomias (Pl. XXIX) growing on glass slides and yielded facts of high interest, especially in connection with Professor Lacaze-Duthier's observations on the adult. In the young the three muscles, adductor, posterior pedal and byssal, are widely separated, though in the adult they almost come in contact, rendering their nature ambiguous. The byssus of Anomia was seen to originate from a cleft in the foot and in the young consists of separate threads. The calcareous plug is formed by the aggregation into parallel lines of separate disc-like centres of calcification, each centre being comparable to a separate byssal-thread attachment found in ordinary Pelecypoda which have a byssus. These and other points of habits, anatomy and shell structure are discussed in sections XII and XIII.

The section XIV, entitled Studies of a few other Genera, considers the young of Mytilus, Argina, Venus, Mya, etc., and is intended principally to show the extension of the prodissoconch to other genera besides those with which this paper is more especially concerned. Brief accounts are given of the young of several genera and a comparatively extended description of the development of the siphon and byssal attachment in Mya. The considerations of this section are for the most part of a preliminary nature and it is hoped to give a full description of these and other genera in a future publication.

After studying the prodissoconch in Ostrea and its allies, Pecten, Perna, etc., I have summed up in section XV the evidence of anatomy, shell structure and palæontological occurrence, all of which points towards Nucula or a nuculoid form as the probable ancestral type of which the prodissoconch is the representative in the development of these several genera. Passing to the next section (XVI), I have attempted to give in tabulated form the serial relations existing between the genera studied. These two sections may be considered as the culmination, to which the studies of shell growth at different ages of the individual and in related genera have gradually led.

As a matter of technique I would call attention to the benefit received from the use of drain-pipe traps containing glass, as described in section II. By its means attached forms were studied on a transparent medium and free forms of small size were entrapped and easily found.

For the guidance of readers attention is called to the italicized paragraphs on pages 295 and 300. Every care has been used to give full references to all observations borrowed from authors and equal pains have been taken to give full credit to investigators where their observations seemed similar to mine, or to have bearings on the various facts and conclusions discussed. The facts described and inferences from them not specially credited in this paper are my own.

II. Sources of Material and Methods of Work.

In the summers of 1887 and 1888, several weeks were spent at a fine collecting locality on Buzzards Bay, which is situated on the southern shore of Cape Cod, from which I walked, or rowed, to my laboratory not far off.

The water of the bay is remarkably clear and pure. It is warmed by the Gulf Stream, and also by rising tides which flow over great areas of sun-heated flats. The water is freshened by Monument River, and by brooks and percolating water entering the bay from the low, gravelly shores.

The site chosen for operations is a low-lying neck of land in the township of East Wareham. At this locality a sand bar is formed by the tide as it rises and flows on the one side to Onset and on the other to Buttermilk Bay. The force of the current is very great and it is a noted spot amongst the fishermen for a "set" or "fall" of oyster spat. On the north side of the neck of land a small sinuosity in the shore line forms an almost enclosed pond which is bare at low tide. The greater part of the young Pelecypoda studied, were obtained on the bar and in this pond. For the use of a temporary laboratory, the bar and the pond, I am indebted to Dr. E. B. Larchar. I am also indebted to him for occasional assistance in prosecuting my work.

In studying forms of animal life that become fixed to foreign bodies during their early stages of development, it is an advantage if they can be induced to attach themselves to transparent media, such as glass or mica, so that they may be studied by transmitted light without disturbance under the microscope.

Several attempts have been made by Ryder (62), Horst and Winslow, but with only very partial success, to secure oysters on glass. As I was anxious, if possible, to get oysters growing on glass, in 1887 I tried several methods to accomplish the desired end, which were described in my paper on "Catching Fixed Forms of Animal Life on Transparent Media for Study." The following method was tried and found successful. On the 15th of July, 1887, at the suggestion of Dr. Larchar, earthenware drain-pipes were partially sunk on the sand bar in an upright position, and loosely filled with broken glass. Six-inch and four-inch pipes were used, and at different elevations above the sand. I did not secure any spat in the four-inch pipes. A six-inch pipe sunk nearly to the level of the bar was successful, but in an unlucky day was filled with sand, and the young oysters buried. Six-inch pipes, reaching about ten inches above the bar, were perfectly successful, and on the glass in them I got large numbers of young oysters. During the summer of 1888 the attempt to get oysters on glass was repeated. On the 18th of July, four six-inch drain pipes were sunk perpendicularly on the bar at the lowest point available at low tide. They stood about fifteen inches above the sand. The last of July, four eight-inch pipes were sunk in a similar position, all were filled loosely with broken glass, and met with entire success. The eight-inch pipes were preferred to other sizes as large pieces of glass could be put in them and the spaces between contiguous plates could be more easily maintained. Long strips of glass, two to four inches wide, the trimmings of glaziers, were used. They were arranged perpendicularly in the pipes, and were readily taken out, examined and cleaned. They were cut as required by one of the rotary, hard steel wheels sold by hardware dealers for that purpose. This size of pipe and glass gave such satisfaction that I should use it in future if occasion demanded to the exclusion of other methods that were tried. Suitable conditions for the success of the undertaking were therefore as follows: (1) a strong tide-way, which would bring plenty of free-swimming fry, and afterwards abundant food for their maintenance; (2)

an area of quiet water within the pipe, in which the fry could settle and attach themselves to the smooth glass; (3) the absolute shutting-out of violent currents which would detach them from their precarious abiding places.

I first found spat on the glass on the 25th of July, 1887, and on the 28th took out a pane 6 by 4½ inches square on which I have counted eighty-two young oysters, as it is still in my possession intact. This was only exceptional in the size of the glass, as other pieces bore nearly or quite as many spat proportionally to their area. Spat were secured in the pipes until the 29th of October, 1887, when few were left, large numbers having dropped off by the natural dissolving action of the sea-water upon the organic cement by which they are attached. In 1888 the first oysters were found on glass on August 1st, and they continued to set into the month of September. The lateness was probably due to the comparative coldness of the summer.

Besides oysters, the young of many invertebrates and algæ attached themselves to the glass, affording admirable opportunities for studying them alive and undisturbed. The following attached invertebrates were noted: *Molgula manhattensis*, Verrill; *Balanus balanoides*, Stimpson; Serpulas, and other tubicolous worms; *Crepidula fornicata*, Lam.; *C. plana*, Say; *Ostrea virginiana*, Lister., in profusion; *Anomia glabra*, Verrill, nearly as abundant as the oysters; *Pecten irradians*, Lam., attached by a byssus, both very young and quite large individuals, varying from 4 to 13 mm. in height; *Modiola plicatula*, Lam., attached by a byssus; *Argina pexata*, Gray, attached by a byssus; *Membranipora pilosa*, Farre, often in large sheets; *Escharella variabilis*, Verrill.[1]

The drain-pipes formed a sort of trap, into which many free-moving, crawling, or swimming molluscs found their way. When in the pipe they would have some difficulty in getting out, and much valuable material was thus obtained. The following Gasteropods were found entrapped: *Scalaria lineata*, Say; *Urosalpinx cinerea*, Stimpson. This gasteropod destroys many oysters both young and adults by boring into the shell and killing the animal. I have not seen holes bored by Urosalpinx in Anomias, though they are quite as exposed as are oysters to its attacks. *Littorina litorea*, Menke, was found entrapped, both adults and young, in great abundance. In moving about on the more or less dirt-covered glass, this animal makes a trail by the lingual ribbon with which it assiduously scrapes the glass for its food. The tracks consist of zigzag series of short, parallel lines of cleaned glass, arranged with the longer axes in the direction of the trail. The short lines are almost confluent with the lines of the next succeeding row; being at first nearly confluent on one side and then on the other, producing a zigzag pattern as the animal moves along. *Ilyanassa obsoleta*, Stimpson, was found in great abundance in the pipes. This species makes a track similar to that of Littorina, but much smaller, as might be supposed from the size of the animal. The differences are that the individual, parallel, short lines are less distinctly separable one from another and there is a much larger angle between the successive zigzag series of lines in the track of Ilyanassa, than is the case with the track of Littorina. The last two gasteropods did good

[1] Our sea-anemone, *Metridium marginatum*, attaches itself freely to glass slides when in confinement. The plan of placing glass in enclosed traps would be a desirable and probably successful method to adopt in studying the development of corals where very fine results might be obtained by its employment.

service in eating vegetable growth on the glass, that would have been injurious to the young oysters and other fixed forms, which I was studying.

The following free Pelecypods were also caught in the pipes as entrapped forms; many specimens of young *Mya arenaria*, L., varying from 0.5 mm. to 6 mm. in length, and very young *Venus mercenaria*, L., 0.5 mm. to 2 mm. in length. *Argina pexata* appears again under this list of entrapped forms, as I found a very young specimen 0.75 mm. long which was free. *Pecten irradians* also belongs to both the lists of free and attached forms, a number of unattached individuals varying from 0.75 mm. to 1.5 mm. in height being secured. It is a stage of development preceding the attached byssated stage as described in the text. Occasionally adult Pectens and *Lævicardium mortoni*, Perkins, were entrapped.

A bottle, bearing many oyster spats and Anomias, was washed up on the shore during a storm, showing that they may be caught on glass under other conditions than those afforded by the drain-pipes. Probably the oysters set in the bottle when it was in comparatively deep water, where moderate quiet prevailed.

The nature of my researches was such that young oysters with shells as clean and perfectly preserved as possible were desired. Year-old oysters perfectly cleaned were found very beautifully preserved in the inside whorls of a dead Sycotopus shell, where they were completely protected from all eroding action. To imitate these conditions, in the salt-pond above referred to, a large number of inverted flower-pots, two-and-a-half and three inches in diameter, were suspended from galvanized wire stretched between stakes driven firmly into the sand. The pots were raised about six inches from the sand. This met with entire success, the pots in many instances being almost literally covered with spat. On the outside of the pots very little, and on the inside no sediment was deposited, as the pots hung like suspended bell-jars, so that the oysters were clean and well preserved. Further, on account of the porosity of the earthenware, the oysters had less hold than on natural cultch of stones and shells, and were easily removed for study. The owner of the pond in the winter of 1887 built a dam across the entrance so as to hold about two feet of water in the pond. Under these changed conditions, inverted pots were again suspended on the 17th of July, 1888. Oysters set on pots quite as successfully as in 1887, when the pots were exposed at low tide, and they grew much more rapidly.

In four large inverted pots microscope slide boxes filled with slides were suspended. The boxes were strengthened by brass nails, as they were simply glued and would have fallen apart in the water. One hundred slides were thus exposed in an horizontal position, but they were not as successful as glass exposed in the drain-pipes. They became coated with sediment on their upper faces and covered with minute vegetable and animal growths on their lower faces. The last is ascribed to the fact that the slides were so close to one another that the scavenger gasteropods, Littorina and Ilyanassa, could not get at them and destroy the objectionable growths as they did in the loosely-filled drain pipes.

In 1887, a number of wooden plates, such as are used at picnics, were exposed in the salt-pond. Holes were punched in the plates which were then strung on galvanized iron

wire and suspended between stakes. The plates were placed in pairs with the edges apposed so that the centres were widely separated and chambered pockets were thus formed. They were fairly successful. In 1888 when the pond was continually full the plates worked more successfully, the oysters growing with extreme rapidity. The rapid growth was probably due to the fact that the oysters were suspended and therefore kept very clean and also to the increased warmth of the water in the shallow pond as compared with water in the open bay. In the chambers formed by the apposed plates, similar forms to those found in the drain pipes were attached or entrapped. The value of obtaining fixed forms like oysters on thin wood is that they are easily removed for study or may be decalcified and sectioned without removal. Should wooden plates be desired, it is best to secure those which are cut from the block in a dish-form, not those which are cut flat and then pressed into a dish-form; because the latter flatten out when exposed in water, whereas the former retain their curved shape.

Cocaine was found a most valuable reagent in paralyzing Pelecypods which it was wished to kill distended or to dissect alive. A four per cent solution was used and was added gradually to a small volume of sea-water containing the animal. By this means only was I successful in killing young Pectens with the byssal attachment intact. Additional material was collected at various localities near Boston and some was loaned me by museums as noted in the text.

III. Classification of Stages of Growth and Decline.

In successive stages of growth of the individual, peculiarities are often found which are characteristic of definite periods. These periodical characters have been studied, especially in their later phases, by Professor Hyatt in fossil Cephalopods, and as a convenience in considering the several periods, he has (33–4) devised a nomenclature of the stages of growth and decline,[1] which he believes is applicable throughout the animal kingdom.[2]

We will now consider this classification in its application to the mollusca. The nomenclature devised for early embryonic stages consists of names very broadly recalling the grand divisions of the animal kingdom. They are protembryo, mesembryo and metembryo. The following names, neoembryo and typembryo, are applied to later stages of embryonic development.

Professor Hyatt considers that the neoembryo mollusc is the trochosphere stage, and that it has not yet acquired characters peculiar to a mollusc. The trochosphere stage (Pl. xxiii, figs. 3–4), before the formation of the shell-gland, certainly has not yet acquired characters which would define it as a mollusc, and we would limit the neoembryo stage to that period of development.[3] A comparison of this stage in molluscs with Pro-

[1] Besides the references cited, this paper was published in the American Naturalist October, 1888. An abstract was published in Science, Vol. xi, No. 260.

[2] Professor Hyatt says that his nomenclature is similar to that adopted by Professor Haeckel; but is also supplementary, and based on morphological, rather than on physiological grounds. In his paper he discusses the relations of the two systems of nomenclature.

[3] The ideal trochosphere of Professor Lankester (41) as that author says: " . . . exactly agrees with the larval form of many Chætopod worms and other Cœlomata; most remarkable is its agreement with the adult form of the wheel animalcules or Rotifera . . . ." Again he says: "So far the young mollusc has not reached a definitely molluscan stage of development, being only in a condition common to it and 'other Cœlomata.'" Some of

fessor Hatschek's figures (36–53) of developing Euponatus (Serpula) shows a close similarity in structure, proving the identity of the two types at this early stage.

The name typembryo Professor Hyatt applies to the period in developing animals when the characteristics of the greater divisions begin to appear; when the embryo has characteristic features of the sub-kingdom to which it belongs. He considers the typembryo of molluscs to be the veliger stage, at which period the embryo is sufficiently far advanced to be recognizable as a mollusc. He speaks of the protoconch (completed embryonic shell) as a typembryo.

I think Professor Hyatt has not given the necessary limitations to his typembryo period in the mollusca. The shell-gland which produces the first rudiments of the primitive shell is considered characteristic of all molluscs (*vide* p. 297). It is the first definitely molluscan feature to appear, and as it is singularly alike in all molluscs where known, the embryo at the period when the shell-gland exists is referable to the mollusca; but has no characters yet which refer it to the class or phylum to which it properly belongs. The veliger stage, however, is referable, not only to the sub-kingdom mollusca as claimed by Professor Hyatt, but also to that class of mollusca to which the embryo really belongs. The veliger Pelecypod, fig. 25, p. 300, Pl. XXIII, figs. 9–11, has two valves and an anterior adductor muscle; the veliger Gasteropod, Pl. XXIII, fig. 19, has a spirally twisted shell and characteristic foot, tentacles and eyes; the veliger Scaphopod, Pl. XXIII, figs. 13–14, has a saddle-shaped shell known nowhere else in developing molluscs; the veliger Pteropod has an anatomy peculiar to itself. I would therefore suggest an alteration in Professor Hyatt's definition of the typembryo. In the mollusca the *typembryo is the period characterized by the existence of a shell-gland and the plate-like beginnings of a shell;* in it normally the ciliated trochosphere disc is becoming transformed into the velum and the foot is developing. Examples of typembryo molluscs are given in the summary of stages later.

I have shown that the veliger stage of molluscs is referable to the class or phylum to which the embryo really belongs. As it is a period most distinct and important, I suggest for it the name *phylembryo.*[1] *The phylembryonic mollusc is an early period in development, yet having characters in the shell and anatomy which make it referable to the class to which it belongs.* Commonly a velum exists at this stage; but the stage is not meant to include the whole veliger period.[2] Examples of phylembryos are given in the summary of stages.

The completed protoconch and prodissoconch of molluscs is a period later than that at which the phylembryonic features are fixed and yet is very distinct from the period

Lankester's and Balfour's figures of the trochosphere stage have already acquired a shell gland and in regard to this character cannot be considered as purely trochospheres according to Lankester's definition, for, with the shell gland they acquire a feature which makes them referable to the mollusca. They are trochospheres in which characters typically occurring later are very early inherited so as to cause an overlapping of stages.

[1] φυλον, a race, tribe stock, phylum, and Ἔμβρυον, an embryo.

[2] The existence of a velum cannot be used very closely as a diagnostic character in considering stages of growth. It is frequently nearly or quite absent, as in Unio, Anodon, Pl. XXIII, figs. 7–8, Cyclas, and Spharium, Pl. XXX, fig. 4, or it may exist long after the period of its normal disappearance. In studies of developing *Sycotopus canaliculatus*, Pl. XXIII, fig. 20, I have found that a large, highly developed velum exists for a considerable time after the formation of the true shell, although it is lost before the young leave the egg cases.

of growth which immediately succeeds it (see figures referred to in the summary). In view of the fact that it is the close of the embryonic shell period and is expressible as a completed protoconch or prodissoconch, I do not think it is necessary to name the period of growth. The period in Pelecypods and Gasteropods, where both anatomy and shell are known in many genera, is referable in origin to the adults of known allied forms.

In the early period of growth of the true shell, which succeeds the first formed embryonic shell, stages have been found which are referable to adult ancestral forms. Professor Hyatt studied these stages in Cephalopods and named them the silphologic (grub) stages. In a footnote to this paper[1] he has given up the use of the term silphologic and supplied in place of it the word nepionic.[2]

My investigations of young Pelecypods and Gasteropods, and also studies of published figures of Scaphopods, lead to the conclusion that nepionic stages in molluscs have characters referable to ancestry in most cases quite close to those naturally grouped as near allies of the adult. In the nepionic period (see figures referred in the Summary), it is quite common to find a shell with characters almost inseparable from those of the adult, or at least so near that the genus can be correctly determined. In other cases, on the contrary, wide differences from the adult condition may be observed at this early stage.

Periods later than nepionic are named by Professor Hyatt successively as nealogic (youthful), ephebolic (adult), and geratologic (old age) stages.

We will now give a brief summary of the stages of growth and decline as applied to the mollusca, with figures or references to known forms which may be used as types illustrative of the various stages. The illustration of the stages is a new feature, not given in Professor Hyatt's paper. Definitions in this summary are taken from that author's paper with the exception of such alterations as are suggested in the foregoing pages.

A classification of stages of growth and decline, in its application to the various groups of the animal kingdom, must be separately worked out for each group. It is believed, however, that the following classification contains the essential features necessary for such applications. New terms may be needed in some groups, but those here used will probably be applicable to the principal periods of growth in all animals.

Protembryo. The ovum and stages of segmentation of the egg preceding the formation of the blastula cavity. Examples: figs. 10–15, p. 295, of developing Ostrea, also Professor Brooks' figures 1–25 of a developing oyster and Dr. Patten's figures 2–14 of developing Patella.

[1] The use of the word "silphologic" derived from σίλφη, a grub, when applied to the younger stages of all animals is likely to lead to confusion of ideas. I have ascertained, by recent studies of insects, the truth of Brauer's opinion, that the grubs, maggots and caterpillars common among insects are not normal progressive stages of development, such as are most common in other types of animals; but are, strictly speaking, cases of retrogressive or more or less degraded specializations. I desire, therefore, to give up the use as a general term of the word *Silphologic* and propose in its place *Nepionic*, or young animal, from Νήπιος, an infant. This word also is more in accord with other terms of the nomenclature proposed in my paper on "Values in Classification of the Stages of Growth and Decline," Proc. Bost. Soc. Nat. Hist. Vol. XXIII, 1888. Signed, ALPHEUS HYATT.

[2] The word nepionic is particularly suitable for early yet post embryonic stages. Besides its meaning of infant, applied to the young of man, I am told by Mr. Ernest Jackson that it is used twice in the Iliad, of young animals, and by Theophrastus of young plants.

Mesembryo. The hollow blastula stage comparable to the condition found in the adults of Volvox and Eudorina types of the Mesozoa.[1] Examples: Pl. XXIII, figs. 1, 1*a*, of developing Patella.

Metembryo. The gastrula, comparable to the lower Porifera in which three cell-layers exist, as in the lowest Hydrozoa. Examples: Pl. XXIII, fig. 2, of developing Paludina, also Hatschek's figure 5, of developing Teredo.

Neoembryo. The trochosphere. Stages not yet possessing the essential diagnostic characters of the mollusca; comparable to the embryos of Chætopod worms and other Cœlomata. Examples: Pl. XXIII, figs. 3–4, of developing Patella, also Professor Butschli's figure 6, of developing Paludina.

Typembryo. The period at which an essential molluscan feature, the shell-gland, and plate-like beginning of the shell are discoverable, and yet the embryo is not referable to the class to which it properly belongs. Examples: fig. 22, p. 297, of developing Ostrea; Pl. XXIII, fig. 5, of developing Pisidum; Pl. XXIII, fig. 6, of developing Pleurobranchidium, also Lankester's (44), fig. 72, of developing Limnæus. A comparison of the molluscan typembryo and neoembryo stages with Hatschek's figs. 36–53, of a developing Eupomatus (Serpula) shows graphically the value of these stages in classification.

Phylembryo. Early veliger stages in which the characters of the class subdivisions are indicated, and the structure of the shell and other features render the embryo referable to the group of mollusca to which it belongs. Examples: p. 299, figs. 23–24, of developing Ostrea; Pl. XXIII, fig. 19, of developing Sycotopus and Pl. XXIII, fig. 13, of developing Dentalium, also Lankester's (43), Pl. 8, fig. 22, of developing Apysia, and our figs. 7–11, Pl. XXIII, of developing Anodon, Modiola, Cardium and Montacuta.

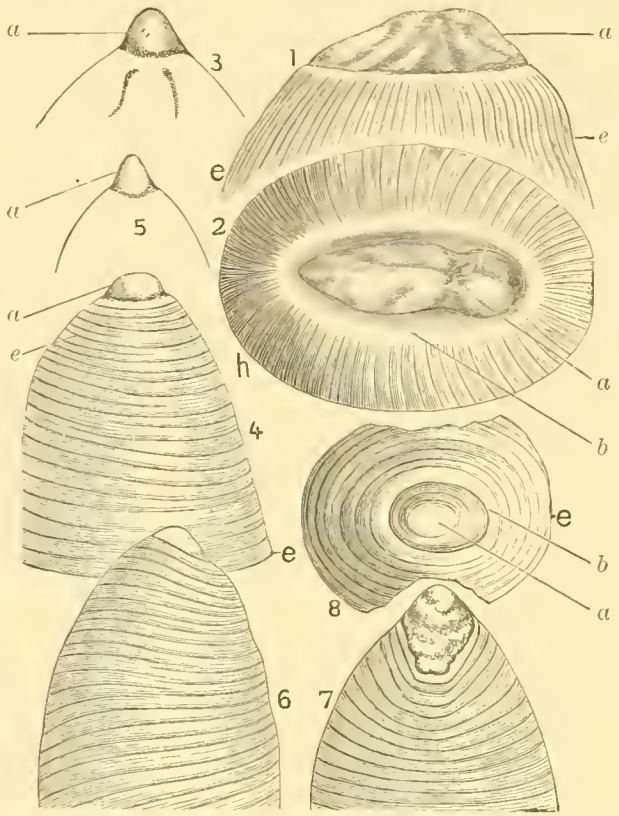
Completed protoconch and prodissoconch. The completed first-formed shell of molluscs, the ovisac, fry shell, embryonic shell and larval shell of authors. It finds its representative in the globular, cup-shaped, or spirally coiled protoconch of Cephalopods. Examples: Pl. XXIII, figs. 15, 16, of developing Goniates. Also see Professor Hyatt's (27) figures of developing Ammonites and Zittel's figures of young Ammonites, Belemnites and Spirula. The existence of a cicatrix at the base of the conch in Nautiloids is claimed by Professor Hyatt (27) as proof that a protoconch existed in the young and a parallel fact in favor of this conclusion is the finding of a cicatrix at the tip of the conch in Aemæa as described below.

A withered, irregular bulb, found at the apex of the conch in some Orthoceratites, figs. 1–8, Professor Hyatt considers as the remains of a protoconch, probably originally of conchyolin structure. M. Barrande (3) figures cicatrices and withered bulb-like protoconchs in many Nautiloids. See his figures of Cephalopoda, Pls. 487–490, inclusive. Several of his figures are taken from unpublished drawings of Professor Hyatt's.

In some Pteropods a bulb-like expansion of the tip of the shell seems to be the equivalent of the protoconch in other mollusks. Examples: Pl. XXIII, fig. 17, also several figures in Bronn's Thier-reichs. In well-preserved Tentaculites a globular or elongate protoconch is sometimes found. Examples: *Tentaculites acuarius*, Pl. XXIII, fig. 18; also see figures in Hall's Palæontology of New York and other authors.

[1] For the consideration of Volvox and Eudorina as mesozoa see Hyatt, Reference No. 30.

The protoconch in Gasteropods is represented by a spirally twisted embryonic shell.[1] Examples: *Sycotopus canaliculatus*, Gill, Pl. XXIII, fig. 19. Older specimens than this from egg cases show a well-marked protoconch at the tip of the conch and I have also observed a well-defined protoconch in young specimens of *Fulgur carica*, Con., *Purpura lapillus*, Lam., *Vermetus radicula*, St., *Buccinum undatum*, L., and *Crepidula for-*



FIGS. 1–3. *Orthoceras elegans*, Münst. Apex of conch and protoconch, viewed from the side, below and in front.
FIGS. 4–5. Apex and protoconch of another specimen.
FIGS. 6–8. *Orthoceras politum*, Klipst. Apex of conch and protoconch viewed from the sides and below.
a, protoconch; *e*, apex of conch; *b*, shoulder of apex.
All from the Triassic of St. Cassian (after Hyatt).

nicata,[2] Pl. XXIII, figs. 21 and 23. Eolis has been figured with an embryonic shell and it is important that this genus which possesses no shell in the adult has a typical, spiral protoconch when young. A very interesting condition is that which I recently found in the young of *Acmæa testudinalis* var. *alveus*, Verrill, Pl. XXIII, fig. 24, which I collected at Vineyard Haven, Martha's Vineyard. No protoconch exists at the apex of the conch;

[1] The embryonic shell or protoconch of Gasteropods is commonly spoken of by embryologists as a "Nautiloid" shell; but this is not strictly correct. A Nautiloid shell is spirally coiled in one plane as in the Nautilus from which the name is borrowed; but the protoconch of Gasteropods, in all the numerous cases which I have seen, either as specimens or figures, is coiled in a spiral plane and should not be confounded with the Nautiloid form from which it is totally distinct.

[2] The spirally twisted protoconch of Crepidula proves that the almost conical form of the adult is not due to a primitive, simple condition in which the spiral has not yet become developed; but rather to a modified condition in which the ancient spiral form, shadowed in the protoconch, is almost entirely lost in the adult. Similar observations have been made on Fissurella in an exhaustive paper by M. Boutan. The protoconch is very sharply defined and is beautifully clear in the young of *Crepidula fornicata*, Lam., and *C. plana*, Say, both of which species are common on our shores and may be collected in abundance in July and August. A short paper on this shell is now in preparation for publication.

but, instead, a well-defined cicatrix marks the position where the protoconch has become separated off. The cicatrix consists of granular lime and fills as a plug the space which otherwise would be a foraminal opening in the shell. In form the cicatrix simulates the outline of the base of the separated protoconch as will be evident by comparing the scar of fig. 24 with the protoconch of Crepidula in Pl. XXIII, fig. 23. The cicatrix of Acmæa is made up of two areas, one circular and surrounded by a ring of similar nature, the other roughly triangular ovate. I find that a similar outline is formed by laying a small, slightly muddy Gasteropod on a clean glass slide. The closely related genus Patella from Patten's studies is known to have a typical spiral protoconch. Therefore, there can be no question as to the meaning of the cicatrix in Acmæa. Professor Hyatt assumed, as noted above, that the existence of a cicatrix in Nautilus predicated the presence of a protoconch in the young and it gives me great pleasure to offer this corroborative evidence of the truth of his assumption from another class of molluses.

In Scaphopods the embryonic shell has been named a periconeh by Professor Hyatt (33) on account of its peculiar saddle-shape form. See Dentalium, Pl. XXIII, figs. 13–14. In Pelecypods the bivalvular embryonic shell or prodissoconch is figured in many genera in this paper. Examples: see almost every plate.

Nepionic period. The period of the first formation of the true shell which succeeds the embryonic shell and is normally retained throughout the rest of life. The period is commonly characterized by marked stages. Examples: figures of developing Ostrea, Pls. XXIV and XXV, figures of developing Perna, Pecten, Anomia, Argina and other young Pelecypods figured on Pls. XXVII to XXX, inclusive. Also Professor Hyatt's (27) Pl. IV, figs. 7–9, of a young *Nautilus koninckii.* These last figures have a smooth, nepionic period, succeeded by a fluted, neologic stage. The nepionic stage is shown in *Crepidula fornicata* and in *Acmæa testudinalis* var. *alveus*, Pl. XXIII, figs. 21, 23, 24. It may be observed in Sycotopus, Fulgur and Buccinum when removed from their egg cases, in which condition the shell is very finely preserved.

Nealogic period. The period succeeding the nepionic and preceding that period which may properly be considered as the adult. It is frequently characterized by marked stages, being a period in which the growing animal often differs widely from the adult, and as it is of considerable size, the differences and stage are easily recognized. Examples: *Hinnites cortesi*, Pl. XXVI, figs. 3–4, has a pecteniform nealogic stage sharply marked off from the ostreaform adult condition. *Slava fibrosa* from the paleozoic Pl. XXIII, fig. 12, is one of the most striking cases of definition of the nealogic period that I have ever seen. The nealogic stage as shown in the figure is concentrically plicated and is highly arcuate, whereas the succeeding ephebolic period is radially plicated, spread out in a fan-like fashion and is much less arcuate. Many species and individuals of this remarkable genus are figured by M. Barrande. The period is strongly marked in the well-known Clavagella and Aspergillum and the last mentioned genus has a definitely marked nepionic stage as well. The young shell of these two genera has up to the close of the nealogic stage two equal valves. In the adult the bivalvular condition is lost; the two valves having united so as to form a single tubular shell, which by itself would not be recognizable as a Pelecypod. In the Gasteropoda, Vermetus, fig. 9, and Magillus, the nealogic period is close coiled, whereas the adult is loosely coiled and vermiform having

lost nearly all the characteristics in the shell of the Gasteropod form. Marked nepionic and nealogic stages of growth are a striking feature of many Gasteropods as seen in Yetus, Cypræa, Strombus and Pteroceras. These and other stages are also strongly marked in many Cephalopods, where they are described by Professor Hyatt (34 and other papers).

Fig. 9. *Vermetus radicula*. St. (After Verrill.)

Ephebolic period. That period best characterized by saying that in it the adult characters find fullest expression; it is often separable by marked stages from the earlier nealogic period, and also from the later or senile period. As examples we would refer to the adult (middle age) condition of the figures referred to as illustrating the nealogic period and also the next or geratologic period. In *Slava fibrosa*, Pl. XXIII, fig. 12, the radially plicated area is referable to the ephebolic period. In *Hinnites cortesi*, Pl. XXVI, figs. 3–4, the ostreaform stage is ephebolic and in *Vermetus radicula*, fig. 9, the verniform stage is the ephebolic period.

Geratologic period. The period of decline of the individual, often marked by distinct stages. The geratologic period is subdivided by Professor Hyatt into the clinologic and nostologic periods, signifying the early and later periods of decline of the individual. As examples of geratologic stages, I would refer to *Venus Tridacnoides* from the Miocene Tertiary of this country and to *Cardita planicosta*, Say, from the Eocene Tertiary of Claiborne, Ala. In both forms old age is strongly indicated by a loss of costations and other characters found in the ephebolic period, the new period assuming a strikingly different appearance. In the old age of a Brachiopod, *Atrypa rugosa*, may be observed a most marked change; the regular even plications of the adult become irregular and spread out in a fan-shaped fashion. This is shown in many of M. Barrande's figures and is more or less completely developed in some specimens of any large collection of American or European specimens.

IV. Ostrea: Development of the soft parts.

Embryology.

The early embryonic development of the oyster may be followed in the writings of Dr. R. Horst on the European oyster, *O. edulis*, L., and Professor W. K. Brooks on the development of our oyster, *O. virginiana*, Lister. The later stages of development have been described by Professor Huxley and Dr. R. Horst in the European oyster, and Professor J. A. Ryder and the author in our species.

The European species, *Ostrea edulis*, L., is hermaphroditic according to European investigators and Professor Ryder, and the embryos undergo considerable development in the gill chambers of the parent. Our species, *O. virginiana*, Lister, on the contrary, is not hermaphroditic, according to Brooks (9), and Ryder (61), and differs from *O. edulis* in that the eggs are discharged from the parent and undergo their whole development in the sea. It produces many more eggs than the European species, and the embryos are much smaller than those of *O. edulis*.

I have not followed the early embryonic development of the oyster, and therefore, for the stages considered make reference to the publications of Professor Brooks (9), Dr. Horst (23, 24) and Professor Huxley (26).[1]

As will be seen in studying the oyster both the soft parts and the hard, we have to deal with a member of a highly peculiar and aberrant group, varying much from the characters commonly met with in molluscs. Many of the characters, and especially their period of occurrence in the life of the individual, are well explained by the law of concentration and acceleration of development, which is considered in the introduction. By this law a highly modified or "concentrated" type is one which acquires characteristics very early in its development, earlier than the normal, so to speak, and such is found to be the case in a marked degree in the oyster.

The egg after fertilization undergoes a period of segmentation until it becomes a solid mass of cells, see Brooks' figs. 1–29 and our figs. 10–15. These stages, following our classification, are considered as protembryo stages. (Nomenclature of stages, section III.)

FIG. 10.

FIG. 11.

FIG. 12.

FIG. 13.

FIG. 14.

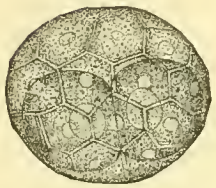


FIG. 15.

FIG. 16.

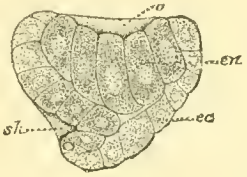


FIG. 17.

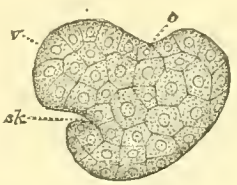


FIG. 18.

DEVELOPMENT OF OSTREA EDULIS (AFTER HORST).

FIG. 10. Egg of oyster, with germinal vesicle and spot visible within the vitellus.

FIG. 11. Beginning of development; the germinal vesicle has become invisible and polar globules appear.

FIG. 12. First stage of segmentation; the egg is divided into two spheres of unequal size (animal and vegetative).

FIG. 13. More advanced, the egg being divided into four spherules.

FIG. 14. Stage when the egg shows one large vegetative sphere and several animal spheres.

FIG. 15. More advanced stage seen from above, where the vegetative sphere is divided into two spherules.

FIG. 16. Embryo side view at the beginning of invagination (gastrular).

FIG. 17. Embryo more developed; optical section, with invagination of the entoderm and beginning of the preconchylian gland: *ec*, ectoderm; *en*, entoderm; *o*, blastopore; *sk*, preconchylian gland.

FIG. 18. Embryo a little older, side view: *v*, pediform appendix; other letters as in fig. 17.

The next stage in the development of the embryo, taking as a normal that which has been commonly observed by embryologists, should be the formation of a morula stage, the cells arranging themselves in a peripheral layer around a hollow sphere. According to the investigations of Professor Brooks and Dr. Horst, there is no true morula stage

[1] In the consideration of these early stages such points are selected from the writings referred to as serve to illustrate this paper. I do not pretend in any sense to give an abstract or even a discussion excepting in a limited sense of the early development.

in the oyster, the gastrula invagination commencing before the formation of a hollow sphere. We have, therefore, no stage comparable to our mesembryo stage, Pl. XXIII, figs. 1, 1*a*, its absence being explicable as a case of extreme concentration of development in the oyster.

In the later segmentation stages, Brooks' figs. 22–28, also our fig. 14, we find that those cells which are of ectodermic and entodermic nature are clearly defined. The entoderm consists of a single macromeric cell surrounded in an increasing degree by micromeric cells up to the period shown by Brooks' fig. 26. The single macromere then divides into two, Brooks' fig. 28, then into several cells, his fig. 30. Coincident with the splitting up of the entodermic cells there is, according to both Brooks' figures and our fig. 16, a flattening of the embryo from above downwards, and a pushing in of the entodermic cells, which commencing as a slight depression, Brooks' fig. 31, our fig. 16, soon forms a deep invagination, the gastrula cavity; see Brooks' figs. 32–35 and our fig. 17.

From this point on there are some important differences in the observations of Professor Brooks and Dr. Horst. As Horst's observations were made on embryos of *O. edulis*, which are much larger than those of *O. virginiana*, and as they are more in accordance with observations made on the development of other Pelecypoda and mollusca I have for the most part followed them where differences exist.

In our classification of the stages of growth, the metembryo mollusc represents the gastrula stage, Pl. XXIII, fig. 2, being a period in which two well-formed and an incipient third layer exist. Professor Brooks' figures 32–35 represent different aspects of the gastrula oyster according to his observations. His fig. 33, an optical section, shows an embryo with a primitive gastrula cavity and body cavity. It also has a velum slightly developed. These figures answer well the requirements of the metembryo stage and may be said to represent that period in the development of *Ostrea virginiana*.

Dr. Horst, considering the stages (our figs. 16–17) which are referable to the gastrula period, says, "there can however be no question of a genuine invagination because there is no cavity of segmentation; we have here, so to speak, an intermediate form between an embolic gastrula and an epibolic gastrula.[1]" He notes the remarkable fact that coincident with the gastrula invagination at the vegetative pole, there is also a very distinct depression at the other pole, a little below the dorsal side, our fig. 17*sk*. This second invagination by further development (our figs. 18–19) he shows is the beginning of the preconchylian invagination.

The gastrula invagination, according to his figures, begins before the preconchylian invagination; but the latter exists before the completion of the gastrula invagination. Horst's figures do not show any trace of a velum at this period, which is somewhat peculiar, as he represents the oyster as so much more advanced in its molluscan characters than does Brooks, who figures the velum at the gastrula period. The early absence of the velum in *O. edulis* may be connected with the brooding habit of that species, for in Pelecypoda,

[1] According to Hyatt (Larval Theory of the Origin of Tissue, p. 156), in the formation of epibolic gastrulæ the growth of the ectoblast cells is so rapid that the endoblast cells become enclosed, and the gastrula is formed by a process much shorter than is usual in embryos of the embolic type. He accounts for the epibolic gastrula by heredity and extreme concentration of development.

which brood the young, as Unio and Pisidium, the velum is highly reduced or wanting. From Horst, we may gather the conclusion that the metembryo (gastrula) stage in the European oyster, fig. 17, is not a pure gastrula, but has already acquired by concentration of development, some of the characters which would normally appear later.

Professor Brooks says that the primitive blastopore closes over, becomes the dorsal aspect of the embryo and gives rise to the shell; the permanent mouth and anus forming on the opposite side of the embryo and independent of the blastopore. This differs so essentially from the observations of Dr. Horst in the European oyster and from those of other investigators except Rabl, in the development of various groups of mollusca, that we prefer to follow Dr. Horst's observations. Professor Brooks himself says (9), p. 76, that the whole evidence furnished by comparative anatomy and embryology tends to show that the mouth, anus and shell-gland can be homologized perfectly in all the classes of true molluscs and that they are not only homologous with each other, but must be perfectly homologous also with similar structures in the ancestral form of which the molluscs are modifications. It is evident that these several organs would not be "perfectly homologous" if in one case the shell-gland arose from the closed blastopore and in another from the opposite pole of the body, and the same would be true of the derivation of the mouth and anus.

Dr. Horst in considering the development of the preconchylian gland[1] says that when the embryo is viewed from the side the glandular depression is seen as in our fig. 18, *sk*, and in fig. 17 in optical section. During the further development, our figs. 19 and 21, a small

Fig. 19.

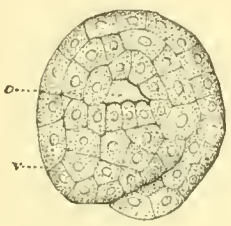


Fig. 20.

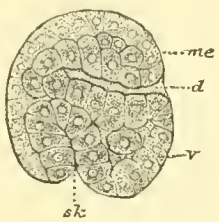


Fig. 21.

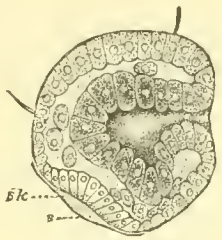


Fig. 22.

DEVELOPMENT OF OSTREA EDULIS (AFTER HORST).

Fig. 19. Embryo same stage as fig. 18, optical section; *me*, mesoderm; *d*, primary gastrula invagination; *sk*, shell-gland.

Fig. 20. Embryo a day older, front view, with the primitive mouth opening.

Fig. 21. The same embryo, optical section.

Fig. 22. Embryo a day older, with a wreath of vibratile cilia, a stomachic cavity and the beginning of a shell, *s*.

invagination is formed bordered by walls of high cylindrical cells with a narrow opening.

Considering fig. 19, Horst says that the gastrula cavity has deepened, and behind the mouth are cells, probably mesodermic. The blastopore continues to be very distinct, and as far as he could ascertain, it did not disappear but remained and was transformed into the mouth.

[1] The preconchylian gland was discovered by Lankester (44) in 1871, and has been figured by him (44) in Loligo, Aplysia, Pleurobranchidium, Limnæus and Pisidium. It has also been observed and figured by Fol in a Heteropod (see Balfour); by Rabl in Planorbis (see Claus); by Butschli, in Paludina (see Claus); by Bobretsky, in Nassa (see Balfour); by Patten, in Patella; by Brooks in a pulmonate Gasteropod; by Hatschek, in Teredo; by Horst in Ostrea and in other genera by various investigators. This array of genera confirms the opinion of Lankester that it is typical of all developing molluscs.

Dr. Horst says that great changes take place during further growth of the embryo. The preconchylian gland gradually loses its primitive character of a glandular invagination and forms a thickening of the ectoderm composed of long, conical cells, fig. 22, *sk*. A thin, cuticular membrane secreted by these cells is the first indication of the shell, and at this position in the adult the hinge is found.[1] Horst maintains, therefore, that the shell of the oyster originates as a single plate in accordance with the observations of Brooks in Anodon and Hatschek in Teredo.[2] Meanwhile in fig. 22 a body cavity has formed by the separation of the ectoderm and entoderm, a velum has developed and the gastrula invagination has formed a spacious cavity in the base of which is a diverticulum, now closed, but which later communicates with the ectoderm and forms the posterior part of the alimentary canal. The neoembryonic mollusc in our classification is represented by the trochosphere stage before the development of the shell-gland, Pl. XXIII, figs. 3–4. In the developing European oyster the shell-gland, according to Horst, originates early, closely following the gastrula invagination and before the formation of a normal trochosphere stage. I think, therefore, that we must consider the neoembryo stage as skipped in the oyster by the overlapping of stages due to extreme concentration and acceleration of development.[3] Fig. 22, on the other hand, is the nearest approach to the ideal typembryo stage that we have in the developing oyster (definition of typembryo, see p. 291). The primitive gastrula cavity has not yet become connected with the ectoderm by the secondary opening, the anus, as is ordinarily the case, but the existence of the shell-gland, with the beginnings of the velum, entitles it to be considered as a typembryo. The existence of these comparatively high characters in the young oyster, at a period when the primitive oral invagination still retains almost its early simplicity and no second alimentary opening has been formed, must be considered as strong proof of the highly concentrated development of this type.

Taking up Horst's account of the developing oyster again, he says that on the following day (our fig. 23) the shell, which has grown very much, covers a large portion of the body. It already contains carbonate of lime, as shown by treatment with acids. Of fig. 24, Horst says, the velum now forms a very distinct part of the body, which is almost entirely covered by the shell. The surface of the velum surrounded by a wreath of vibratile cilia already shows in its centre a thickening which is the beginning of the cephalic shield. An œsophagus in the shape of a funnel leads to a large, pear-shaped

[1] A horny plug, the product of the cells of the shell-gland, has been described in Gasteropoda and Pteropoda (Lankester (44), Balfour). The typical universality of the shell-gland cannot be doubted (note, p. 297) and the ligamentous union of the valves of Pelecypoda occupies the precise position of the shell-gland. It seems reasonable to follow Lankester's suggestion, based on Pisidium (43) and homologize the horny ligament of Pelecypods with the horny plug of embryonic Gasteropods and Pteropods. To quote Lankester, "In Pisidium as will be seen from "Pl. IV, figs. 38*a* and 39, the two calcareous valves do not "make their earliest appearance in close contact one with "the other. The central portion of the shell-gland is not "concerned with them; and since it is precisely that point "which in the Gasteropods cited gives rise to a chitinous "plug, may we not see in the ligament of the bivalve, "which occupies so precisely the required position, the "homologue of that production."

[2] The primitive shell in Cyclas and Unio has also been observed by investigators to begin as a simple, unpaired cup.

[3] Lankester, in his article Mollusca (44), refers to Horst's fig. 14 (our fig. 23) as the trochosphere stage. But as the shell has not only considerably developed, but consists of two valves, we think this figure is referable to the class of Pelecypoda, a period later than the trochosphere stage. Lankester's own definition of the trochosphere is that at this period the embryo has not yet acquired mollusean features and is comparable to the larval forms of many Chætopod worms and other Cœlomata, which is not the case in the figure cited.

stomach which communicates with the outside through the intermediation of an intestinal canal.

Our fig. 23 is distinctly the essential equivalent of Brooks' figs. 38–42. Our fig. 24 again is reasonably close to Brooks' fig. 44. At this last stage there are two well-developed valves, a stomach, mouth and anus, a ciliated foot and a large velum. In fig. 24 a

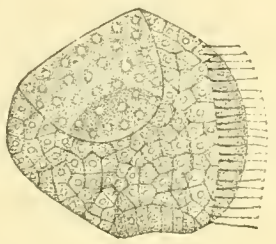


Fig. 23.

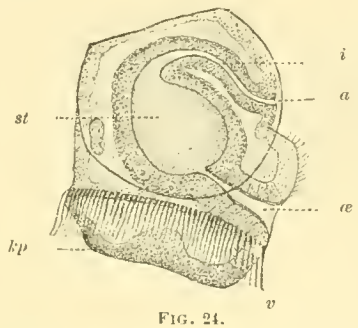


Fig. 24.

DEVELOPMENT OF OSTREA EDULIS (AFTER HORST).

Fig. 23.—Embryo at more advanced stage than fig. 22, side view, with shell more developed.

Fig. 24.—Embryo still more developed; *v*, velum; *œ*, œsophagus; *st*, stomach; *a*, anus; and *kp*, cephalic plate.

body is represented which, although Horst does not mention it, appears to be the beginning of the adductor muscle of the valves. It is in the same position as that occupied by the adductor in Horst's fig. 16, Brooks' fig. 44 and our fig. 25, p. 300.

I have described as the phylembryo an early period of development (see section III) where, however, the class characters are recognizable, and I consider figs. 24–25 as phylembryonic stages of the oyster. They have two equal valves and an anterior adductor muscle, characters which render the embryo referable to the phylum or class Pelecypoda, to which it properly belongs, although not referable to any known adult form.

The mouth and anus when developed arose in close proximity on the ventral border of the embryo, Brooks' fig. 38, our fig. 23, which is a generalized characteristic of a molluscan embryo. It is seen in fig. 24 that the first adductor muscle develops anteriorly and close to the dorsal margin of the velum. The retractor muscles of the velum and liver then develop. The anus, from its early ventral position, revolves dorsally in the plane of the valves (see Brooks' figs. 38–44). The intestine by interstitial growth makes a single loop-like curve on the left side; this with some other slight changes brings us to the stage, fig. 25, described by Huxley (26). Ryder (63), remarking on this stage, notes that the intestine is already flexed on itself in much the same manner as in the adult, though it does not extend as far anteriorly, and its position is modified later by flexions of the stomach and œsophagus.

The shell of the stage, fig. 25, is symmetrical, equivalvular, and of about the period of development of Pl. XXIV, figs. 13–16, of the developing shell of this same species. The mouth has yet no palps, a sac-like process of the stomach on either side represents the liver, two pairs of muscles serve to retract the velum, and the single adductor muscle closes the valves. Huxley observes that this early anterior adductor cannot be the equivalent of the single adductor of the adult as it is on the ventral side of the alimentary canal whereas that of the adult is on the dorsal side. He says that a second posterior

adductor must be developed and this early anterior adductor lost in later development. This was all that was known concerning the development of the adductor muscles of the oyster when I published my preliminary paper in which it was shown that two adductors exist at the completed prodissoconch stage.

A stage of *O. virginiana* of similar age to our fig. 25 of *O. edulis* has been figured by Ryder (62). The valves were nearly disc-shaped, but flattened at the hinge area. A ciliated velum existed, and as Ryder noted, "the embryos appeared to be attached to the glass by a marginal extension of the mantle over the edge of the lower valve, forming a sort of lip," but they were not firmly fixed as "the embryos swung to and fro." He did not succeed with later attempts in getting similar attachments, and from my own observations I have every reason to believe that the fixation was of a transitory nature, not to be confounded with the fixation which young oysters later acquire when they become fixed for life.

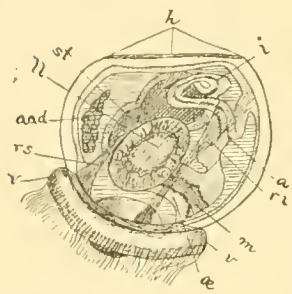


FIG. 25.
EMBRYO OF OSTREA EDULIS L. (AFTER HUXLEY).

The phylembryo stage, viewed from the left side. *a*, *ad*, anterior adductor muscle, which alone exists at this stage; *m*, mouth; *œ*, œsophagus; *a*, anus; *i*, intestine; *st*, stomach; *ll*, left lobe of the liver; *v*, velum; *rs*, *ri*, superior and inferior muscles, which retract the velum into the shell, *sh*; the hinge, *h*, is straight. Compare with Pl. XXIII, figs. 7–11 of phylembryonic stages of developing Pelecypods, where as here the hinge line is straight and the anterior adductor alone exists.

I have thus far considered the early development of the oyster, using facts observed by other investigators. This is done in order to make clear the later portion of the embryological development and also to bring out some facts elucidating the development of the group of Pelecypoda. All later observations are my own, excepting where specially credited.

Between the stage fig. 25, and our next stage, Pl. XXIV, figs. 1–2, there is a blank in the knowledge of the development of the oyster. It has not been described in the European species, and all attempts to obtain it in our species have failed. In artificial confinement the oyster dies at this stage.

The next step in the anatomy which I have to consider is that of the oyster when it has completed the prodissoconch growth and just preceding the beginning of the dissoconch, or "spat growth." This period is the last of the embryonic stages, using as bases of consideration the structure of the soft parts and the hard as well as a comparison with a similar period in other developing Pelecypoda. In my preliminary paper (36) I showed the important fact that the oyster at this stage has two adductor muscles, situated relatively to the alimentary canal as they are in adult dimyarian Pelecypods. The specimen then figured was from alcoholic material collected at Buzzards Bay, and the parts had contracted so that some features were not successfully made out; the muscles however were rendered clear by treating the specimen with dilute acetic acid, and thus dissolving the calcareous shell. Living material of this age was obtained later growing on glass slides, so that it could be studied more satisfactorily.

On the third of August, 1888, clean glass was put into a drain-pipe trap on the sand-bar. The following day it was examined and a young oyster, Pl. XXIV, figs. 1–2, was found attached. No spat growth had taken place, but the embryo was firmly attached by the ventral margin of the left valve. On driving a current of water forcibly over the glass from a pipette it did not rock or move from its position, thus demonstrating

the firmness of the fixation. As the oyster had been attached less than twenty-four hours, the anatomy and shell here represented must have been developed while it was a free, unattached embryo. The fact that the embryonic shell is always fixed by the extreme ventral margins only, is further proof that fixation takes place at the close of this period.

The embryo was yellowish-green and lively, constantly extending and retracting the mantle and gills and moving the palps. The important feature of the two adductor muscles was clearly made out as shown in Pl. XXIV, fig. 1, viewed from the right side, and in fig. 2, viewed from the left side through the transparent glass to which the embryo was attached. The intestine wraps around the dorsal aspect of the posterior adductor, as in all later stages. A large, lobed, ciliated velum still exists and is situated on the ventral aspect of the anterior adductor muscle, lying close up to that body. The ciliated and lobed palps are situated close up behind the velum. Club-shaped, tubular, ciliated gills, Pl. XXIV, fig. 1, also fig. 6, with the tips not recurved upon themselves, exist. The mantle border is broad and thick, bears no tentacles and is capable of considerable extension beyond the margins of the valves. Within the umbo of the lower left valve was a rhythmically, rapidly pulsating body, as of a large blood-vessel. The liver forms a large, light green mass in the upper part of the body and extending into the umbos.

About three and a half hours after the specimen was first seen a slight spat growth had taken place along the ventral margins of the valves. It was kept alive several days, during which growth proceeded rapidly and was studied at intervals; Pl. XXIV, fig. 3, being three days older than figs. 1 and 2. We will now discuss this stage, which is of great importance, both in the development of the oyster and related Pelecypoda as well.

The anterior adductor muscle of the early development, fig. 25, p. 300, is still existent in this stage, Pl. XXIV, figs. 1–2, *a*, *ad*, but there is another muscle, the posterior adductor, as well. We have then the interesting feature of a monomyarian Pelecypod in its early stages possessing two muscles, situated relatively to the alimentary canal as they are in typical adult dimyarians. The anal part of the intestine revolves dorsally during the early development of the oyster and the posterior muscle when formed must have originated on the ventral aspect of that organ. If the posterior muscle had developed on the dorsal side of the intestine it would always have retained that relative position as the permanent anterior adductor of dimyarians does in relation to the mouth and œsophagus. One of the striking characteristics of the ostrean prodissoconch is, that the umbos point posteriorly as shown in Pl. XXIV, figs. 1–2. This is contrary to the condition observed in developing dimyarians, as in them the umbos point anteriorly, but an exception is found in Nucula, the embryo of which, according to Lovén, has umbos directed posteriorly. This character of the umbos is discussed in its serial connections in section XV.

In Ostrea, fig. 25, indisputably the anterior adductor is first developed; also in Cardium, Modiolaria and Montacuta, Pl. XXIII, figs. 9–11, in Pisidium according to Lankester (43) and in Anodon,[1] Pl. XXIII, figs. 7–8, according to Schierholz[2], the anterior adductor is first developed. I have found only two possible exceptions to the rule of the

[1] In the embryo of Anodon, Pl. XXIII, figs. 7–8, the first formed adductor muscle is in the larger side of the shell. According to Schmidt's figure of a later stage, the larger side is the anterior end of the embryo. Therefore the first formed adductor is probably in part, at least, the beginning of the permanent anterior adductor as in the other Pelecypoda above considered.

[2] Schierholz' paper, see Schmidt's reference list.

anterior adductor being developed first. These are Mytilus and Unio. As the nearly related Modiola and Anodon follow the rule these two genera may be considered as exceptions, or perhaps illustrate errors of observation as discussed in my preliminary paper, (35), p. 535.

In Ostrea the mouth and anus develop ventrally, the anal extremity of the intestine revolves dorsally and the anterior adductor is developed. Later, the posterior adductor develops on the ventral side of the intestine. When one compares this with the figures and descriptions of the development of the above-mentioned genera (excepting Mytilus and Unio), together with the anatomy of the adults, it seems that there is a close uniformity of plan. The genera mentioned are not numerous, but they are taken from widely separate groups of Pelecypoda. There is then strong evidence in favor of the development of the anterior adductor first in Pelecypods as the typical mode, and the development of the posterior adductor later, after the intestine has revolved into place, from its early ventral position. This theory easily explains the constant relative positions of the mouth and anus to the two adductors in the adults of dimyarians, or to the single adductor, where only one exists, as in monomyarians.

It is seen that there are two distinct stages of development of the muscles of the embryonic oyster. First, a single-muscled stage, the early monomyarian, fig. 25, p. 300, pointing towards a problematical ancestor, which in the adult condition had only one adductor muscle, and that one in the anterior portion of the body.[1] The second stage is the two-muscled stage, dimyarian, Pl. XXIV, figs. 1–2, pointing to an ancestral adult form which had two muscles like the typical dimyarians. The figure of this stage shows the early formed velum to be still existent, but it is not supposed that the early dimyarian, adult ancestor possessed a velum. It exists here presumably because of the lapping over of stages, due to concentrated development, which is most marked in the early embryonic development of the oyster. The shell which covers these stages is continuous in outline.

As stated, a velum still existed at this dimyarian stage, Pl. XXIV, figs. 1–2. The long vibrating cilia were in active motion and some motion of the velum as a whole was noted; but it was not seen to extend beyond the margins of the shell. Attempts have been made by Horst and Ryder (62) to discover the method by which the young oyster attached itself to the object of permanent fixation and both investigators surmised that it might have a brief byssal attachment. Ryder, in considering the fixation of the embryos described by him,[2] thought that it was effected by means of the border of the mantle reflected over the edge of the undermost valve as shown in his figure. The nearest approach to a foot known in the developing oyster is that shown in fig. 24, p. 299, and I discovered no traces of a foot in my youngest specimens. As the byssus is an organ developed in the ventral portion of the foot, the high reduction or almost complete absence of that organ is in itself strongest evidence against the suggestion that the attachment

[1] It is possible that the first formed muscle does not point to an ancestral single-muscled Pelecypod, in which only the anterior adductor was developed. It may point to some muscle in the primitive ancestral mollusc from which the Pelecypoda were derived, and which muscle became the anterior adductor of the Pelecypoda.

[2] The fry described is comparable in age to my Pl. XXIV, figs. 13–16, and is not to be confounded in its attachment with the permanent attachment made at the close of the prodissoconch stage, Pl. XXIV, fig. 17.

of the young oyster is effected by means of a byssus of however short a duration. In my studies of the young of Avicula, Perna, Pecten and Anomia, Pls. XXVII–XXIX, it is shown that a notch for the projection of the byssus, or foot, is marked in the dissoconch shell immediately after the close of the prodissoconch stage. On most careful study no such indications of a byssal attachment were seen on the lower valve of attached oysters, and as they were growing on transparent media, fullest opportunity was enjoyed to make such observations. In view of the evidence it is therefore safe to conclude that the oyster does not have a byssus at any period of its development. The preliminary fixation is probably effected by means of the reflected mantle border, as described by Ryder, and is then immediately succeeded by a cementing conchyolin attachment of the extreme edge of the lower left prodissoconch valve.

The fact that a velum, or swimming organ, exists up to the period of permanent fixation, accounts for the great reduction of the foot, because that organ is unnecessary while the animal is provided with another locomotive organ, and is useless for progression after the animal is permanently attached. The reduction of the foot is clearly attributable to disuse and a high degree of concentration of development. This is another of the cases of extreme concentration of development seen so markedly in the development of the oyster.

The gills of the young oyster, Pl. XXIV, figs. 1–2, and fig. 6, consist of two rows of filamentous appendages, one on either side. They are fixed to the body mass anteriorly, but are free posteriorly, and are capable of considerable dorsal and ventral rotation. Eight club-shaped filaments were counted in either row at this early stage. Each filament is ciliated and perforated by a tube which expands dorsally into a canal connecting the tubes of the several filaments. The filaments are entirely free and separate from one another excepting on their dorsal border and are not bent back upon themselves on their ventral margins as they are in later stages. Each filament represents a hollow bag, or pouch, in which the blood is aerated by water kept in constant motion by the active cilia. This stage of development of the gills is exactly comparable to that figured in the young of Mytilus by Lacaze-Duthiers (41). The condition is also comparable to that described by Mitzukuri in the adult of Nucula excepting that in that genus a pair of filiferous branchiæ exist on either side. After tracing the further development to the adult condition in Ostrea it will be seen that the gills of the other Pelecypoda described are only modifications of this simple early type.

V. Ostrea: Development of the Soft Parts.

The Spat.

At the close of the period just described, the young oyster enters on stages of growth both in the soft and hard parts which are rapidly approaching the conditions characteristic of the family to which it belongs. They are stages distinctly post-embryonic and I shall consider them as the nepionic or babyhood stages.[1]

The young oyster, Pl. XXIV, figs. 1–2, growing on a glass slide, was kept alive in a

[1] For a discussion of the nomenclature of stages *vide* section III.

beaker of sea water for four days. When twenty-four hours older than the figures cited, a good deal of spat growth had taken place; the velum had disappeared and the anterior adductor was difficult to discern, but I think still existed in a position much nearer the hinge margin than in figs. 1–2; the muscle had therefore revolved dorsally. The posterior adductor had not changed much in its position; but the palps had revolved dorsally. The animal was yellowish-green as on the previous day, and the mantle border was wide and actively extended and retracted. The action of the parts was more clearly seen when viewed from the left side through the glass to which it was attached than from the right upper side. From this view many observations were made. The gill filaments at the end of twenty-four hours were not yet joined to one another on their ventral margins as in later stages.

When the same specimen was forty-eight hours older than Pl. XXIV, figs. 1–2, no anterior adductor muscle was seen. The posterior adductor from its earlier position had moved ventrally so that it lay near the border of the prodissoconch valves. The palps had revolved dorsally so that they were situated near the hinge line, but were directed ventrally; a fact to be discussed later. I did not see the radial muscles of the mantle visible in later stages, but they doubtless existed; no marginal tentacles were yet developed. The rhythmical pulsating body, noticed on the first day in the umbo of the left valve, had disappeared or become hidden in the increasing liver follicles. No heart was discovered on the dorsal border of the adductor, where it is later found. The liver was greenish brown, not light green, as at first.

Pl. XXIV, fig. 3, is from the same specimen three days older than figs. 1–2. The spat shell has grown considerably, the posterior adductor has moved to a more ventral position than it occupied forty-eight hours after attachment, and the palps have moved farther dorsally. The gill filaments are now connected on their ventral margins by cross connecting bars, and this is the beginning of the intricate system of cross connecting network, characteristic of the adult ostrean gill. The filaments in young and adult Pecten are joined by interlocking but separable cilia, similarly to those of Mytilus as described by Peck, but the connection in Ostrea is a complete organic union brought about by the concrescence of fleshy processes from the margins of adjoining filaments. The cross bars begin to be developed between the filaments in the anterior portion of the gill and from that region are formed posteriorly in a serial manner between successive filaments. In oysters up to 2.2 mm. in height only a single series of cross bars exist and those are on the ventral margin as in Pl. XXIV, fig. 3. The ends of the gill filaments in the spat, fig. 3, are recurved and joined by concrescence at their tips with the recurved filament tips of the opposed gill-lamella. This is understood by comparing the diagrams of the gills of developing Ostrea of this stage, Pl. XXIV, fig. 7, with those of an adult Pecten, Pl. XXIV, fig. 12. The contiguous surfaces of the direct and reflected portion of the filaments are not organically connected at this early period, so that each gill-lamella represents a hollow cavity bordered by its filamentous walls and a condition similar to this has been observed in adult Perna. The two gills are of about equal size at this period. Horst states that in young *Ostrea edulis* the gills are filamentous, joined only at the bases and tips; and he compares this condition with Lacaze-Duthiers' (41) well-known observations on Mytilus.

We will now consider an oyster, Pl. XXIV, fig. 4, considerably older than our last figure. Ryder (63) published a figure and description of an oyster somewhat younger than this and yet older than my Pl. XXIV, fig. 3. He compared the anatomy of his figure with that of Professor Huxley's figure (my fig. 25, p. 300) and demonstrated serial connections between these and the adult. Pl. XXIV, fig. 4, illustrates a young oyster of the spat stage growing on a glass slide, on August 6, 1888. The single adductor muscle occupies a sub-central position similar to that of the adult. The palps have revolved dorsally and assume a position intermediate between that shown in Pl. XXIV, fig. 3, and that characteristic of the adult, Pl. XXV, fig. 12. They differ from the adult in that the outer pair of palps forms a hood above the mouth which opens downwards and not as directly forwards as in the adult. Both these differences are discussed by Ryder (63). Four palps exist, but they are marked by few (five) furrows on their surface, instead of a great number as in the adult. Ryder observes this difference, and says that though few in the young he has counted over a hundred furrows on one side of the lower palp of an adult.

The heart is situated in a pericardial cavity above the adductor muscle, as in adults. From ninety to one hundred and ten heart-beats per minute were counted. This is a very high number, as Professor Ryder (64) notes that in the adult the heart-beats probably do not exceed twenty per minute. A large pulsating artery, *v*, passes to the mantle border where it is confluent with the posterior tips of the gills, and lesser ramifying arteries bifurcating frequently are spread over the mantle in every direction. These are not shown in the figure as they would confuse other details. The blood corpuscles traversing the arteries may be readily seen through the thin shell as indicated by arrows and, when the heart is beating rapidly, the blood may be seen returning to the heart through the canals on the dorsal border of the gills. It passes out from these canals through the foramina *c* and *d*, and also from between foramen *d* and a point nearer the anterior tips of gills. At *d* the afferent and efferent vessels are connected and though most of the blood from the gills passes into the heart, some corpuscles may be seen joining the efferent current and flowing into the large artery, *v*, which supplies the mantle border.

This specimen growing on glass afforded excellent opportunity to study the gills. The filaments of the two gills, *A*, *A*,' Pl. XXIV, fig. 4, are connected by several rows of cross bars, instead of only a single row on the ventral margin. (Compare with Pl. XXIV, fig. 5.) An oyster, 6 mm. high, was observed to have five cross filaments in the larger gills. The two first gills originated simultaneously as far as known. They began as tubular disconnected bags, as described; by the concrescence of lateral fleshy processes and of the inwardly grown recurved tips of the filaments, their present form, which is diagrammatically shown in Pl. XXIV, fig. 8, has been built up. But this accounts for only two gills and there are four in the adult; the development of the last two gills has not been previously studied, though Ryder (63) states that in very young spat only two are present. When first studied on the sixth of August, the young oyster, Pl. XXIV, fig. 4, besides the two larger gills, *A* and *A'*, had a third very short gill, *B'*, on the right side; but no corresponding, fourth short gill on the left side. The gill *B'* was continuous along the margin of the adjoining gill *A'* for its whole extent. It originated from the same base as did *A'* for the outer border of *A'* was first formed, the inner border be-

ing the reflected portion and of later growth. This will be better understood by comparing the diagrams of the gills of Ostrea, figs. 6–9, with those of Anomia, fig. 11, and Pecten, Pl. XXIV, fig. 12, where the origin and relation of separate gills and gill folds are perfectly clear. The newly formed gill *B'* was composed of the same number of filaments as was the well developed gill *A'*. In dissecting similar specimens it was found that the tips of the filaments of the gill *B'* were already folded back upon themselves, but they are reflected outwardly instead of reflected inwardly (toward the median line of the body) as is the case with the filaments of the first formed gills (again compare with the diagram of gills of Pecten and Anomia). After an interval of two days, a fourth gill, *B*, shown diagrammatically in Pl. XXIV, fig 8, appeared on the left side on the basal margin of *A*. It began as a minute bud-like process and grew as already described for gill *B'*.

In other specimens up to 4.75 mm. in height, a third gill, *B'*, had begun to develop on the right upper side as in Pl. XXIV, fig. 4, but no fourth gill had yet appeared on the left lower side. Oysters of 1 cm. in height had all four gills developed, but in disproportionate degrees. The right outermost was short, the right innermost long, the left innermost longer still, and the left outermost (the last formed) very short, as in the diagram, Pl. XXIV, fig. 8.

First, it is noteworthy that those gills, which are to form the right and left outermost gills of the adult, appear much later than the two innermost gills. Secondly, it is a remarkable and interesting fact that a considerable time elapses between the origination of the right outermost gill *B'* and the left outermost gill *B*. Stoliczka, in his "Cretaceous Pelecypoda," on page 2, says, "I have examined one or two animals of almost every family of the Pelecypoda, and in all I found that there are at least two gill-lamellæ present on either side,—never a single one, though they are often unequal and one of them sometimes, as in the Tellinidæ, nearly obsolete."[1] The late appearance of the third and fourth gills in Ostrea may have phylogenetic significance, but the irregularity of their appearance is probably due to other causes, perhaps due in some way to the pressure exerted on the parts as the oyster lies on the left side in its adopted habit of fixation.

Viewing our specimen from the left side through the glass to which attached, it was found that the dorsal margins of the several gill-lamellæ were not superimposed; the united borders of gill *B'* and the outer lamella of gill *A'* were near the middle line of the valves. The reflected borders of *A'* and *A* united to form a margin nearer the ventral edge of the shell than the previous gill margin. The outer lamella of *A* and the new gill *B*, when formed, made a united border still nearer the edge of the shell. The result of this want of juxtaposition was that, when viewed from the right side, fig. 4, Pl. XXIV, the gill *A* looked much larger than *A'*, because it extended nearer to the margin of the shell. In degree this was untrue, though as a matter of fact *A* is somewhat larger than *A'*. Dr. Pelseneer, in his report on Lamellibranchiata in the Challenger Reports, gives a very clear figure showing the condition and relation to one another of the gill filaments in a large number of genera.

The course of the alimentary tract has been traced in the young oyster by Ryder (63),

[1] According to Dall (16), a single gill-lamella, composed of separated filaments, exists on either side in Dimya. He briefly discusses the relations of the gills and classification on this basis in Bull. Mus. Comp. Zoöl., Vol. XVIII, 1889.

but it may not be amiss to repeat the observations as my specimens, growing on transparent glass, were very clear. In Pl. XXIV, fig. 4, the dotted outlines of the alimentary canal are those portions not visible from the right side, but seen when the oyster was viewed from the left side through the glass microscope slide to which it was attached. From the upper part of the hood-shaped palps a short œsophagus, *œ*, leads directly into the stomach, *st*. The stomach, embedded in greenish-brown liver, has a circuitous outline especially on its ventral border. The intestine leads from the posterior end of the stomach and extends in a nearly direct line to a point half way past the adductor muscle. It then takes a sharp bend and, returning on itself, curves and follows the dorsal outline of the body; again turning when near the umbos, it follows the outline of the body and passes to the left of the œsophagus. It is then produced posteriorly in a curving line, passing to the left at the two points where it crosses the earlier portion of its own track and emerges from the liver mass just above the heart. It passes outside of the heart and wrapping itself around the adductor muscle terminates in close relation to that muscle. This course of the alimentary canal is identical with that figured by Ryder (60), in an adult, excepting that in the adult the œsophagus is directed more anteriorly than in the spat. The fæces, of a peculiar, nearly horse-shoe shape,[1] pass from the intestine in small particles and are carried from the cloacal space by the excurrent water from the gills through the opening, *s*, Pl. XXIV, fig. 4, formed by a sinuosity of the border of the right valve. All water from the body passes out through this opening, as indicated by arrows, and the mantle is retracted to allow of its passage.

A special excurrent passage is characteristic of younger and older spat than the one described (Pl. XXV, figs. 5–6); but no trace of it has been found in the adult. The sinuosity of the right valve is apparently due to the constantly retracted condition of the right mantle border at this point. It is constantly retracted to admit of the passage of the excurrent water and being so retracted, as a necessary result, the shell is not built at this area as rapidly as at other places where the mantle is fully extended. It might be considered that the peculiar excurrent opening was due to the mechanical conditions under which the oyster lives, an opening being necessary on account of the close relation of the shell to the object of fixation, and it is possible that this is the case; but against it may be urged the fact that no such character is found in Anomia which is subject to similar conditions. I think that this excurrent passage and the correlated sinuosity of the right valve are of hereditary significance. Examining the fossils, we find a similar sinuosity of the left and right valve characteristic in marked degree of the genus Gryphæa; it is also found frequently in Exogyra and in many fossil members of the Aviculidæ, from which last group the Ostreadæ were doubtless evolved.[2]

As in the case presented, many peculiarities of the form of shells can doubtless be elucidated by a study of the soft parts and life-habits of the animals. The byssal notch, ridges of large siphonated forms as the Myidæ, and siphonate processes of Gasteropods are examples of such characters, many of which are specially studied in this paper.

[1] The horse-shoe shape is the form of the cross section of the fæces and owes its origin to the peculiar form of the intestine Ryder (60).

[2] In section VII, it is stated that Gryphæa and Exogyra are probably aberrant members of the Ostreadæ, not typical forms in the line of evolution of the group. I do not think this militates against what is above stated. Ostrea has an excurrent sinuosity of the valves similar to that found in Gryphæa and Exogyra, in all, inherited (if at all) from far-off ancestral groups.

The mantle borders of Pl. XXIV, fig. 4, are free throughout their extent, with the exception of a small area near the umbos, where the borders of the two folds are confluent. The margins are thickly set with tentacles which are slightly pigmented with black. When undisturbed and quietly feeding, the mantle stretches out to the margin of the shell on all sides and even protrudes considerably beyond it. It moves actively, being constantly retracted and extended by the radial muscles shown in my figure and described by Ryder (63). The radial muscles are best seen from the left side when the spat is viewed through the glass to which attached, as the lower valve is thinner and less pigmented than is the upper right valve. The marginal tentacles are constantly in motion, being continually elongated and retracted. When elongated they are used with a tentative, feeler-like motion, and if irritated are capable of extreme prolongation. The gills and palps move frequently and suddenly. The adductor muscle in Pl. XXIV, fig. 4, is seen to be composed of two parts, as is that of the adult, Pl. XXV, fig. 12, and a condition of the adductor similar to that of Ostrea is seen in Perna.

During later stages of growth the soft parts rapidly assume the form, structure and position which they occupy in the adult, Pl. XXV, fig. 12. The mouth parts are revolved towards the umbos and the anus and adductor are revolved in the opposite direction, towards the free ends of the valves. The gills increase in complexity by the development of cross partitions within the gill chambers, between the contiguous faces of the direct and reflected portions of each gill lamella. These partitions form walls joining gill filaments and separated from succeeding walls by eight or ten filaments not so joined. Their existence gives rise to the folds characteristic of the adult oyster's gill. Large water tubes are thus formed, each tube bordered by eight or ten gill filaments on either side with their network of cross bars.

An epitome will now be given of the changes by which the adductor muscles of the young oyster become transformed into those of the adult and the relation of these changes to what exists in other adult Pelecypods is discussed. The embryo first passes through an early single-muscled stage, fig. 25, p. 300, in which the single adductor is the equivalent of the anterior adductor of dimyarians. This stage, as stated I believe, is a typical early stage of all Pelecypod embryos.[1] Later, the oyster has two adductors, Pl. XXIV, figs. 1–2, entitling it to ancestral kinship with dimyarian Pelecypoda. Finally the anterior adductor is lost, and the remaining posterior muscle is alone retained.

In the embryonic oyster, fig. 23, p. 299, the mouth and anus are closely approximated on the ventral aspect of the body. Passing to figs. 24 and 25, pp. 299–300, the anterior adductor muscle has developed, and the anus has revolved dorsally. In Pl. XXIV, figs. 1–2, the posterior adductor has developed on the ventral side of the intestine, which wraps around that organ as in later stages, and in all adult Pelecypods. In the last figures the velum, interposed between the anterior adductor muscle and the mouth, prevents the mouth revolving dorsally as it otherwise might have done. Passing to Pl. XXIV, fig. 3, the mouth has revolved dorsally similarly to the anus, and lies nearer the umbos than in previous stages. However, as noted by Ryder (63) in his studies, it still opens downward and not as directly forward as in the adult. In Pl. XXIV, fig. 4, the mouth lies still nearer to the umbos of the valves and from this stage to the adult, Pl. XXV,

[1] *Vide* p. 280, and section XV.

fig. 12, where it immediately underlies the umbos, and opens toward them is merely a series of mechanical stages. Correlatively with the dorsal revolution of the mouth the anterior adductor muscle has disappeared in the growing oyster.

In the dimyarian stage of the young oyster, Pl. XXIV, figs. 1–2, the relative position of the axis of the body to the hinge axis of the shell[1] resembles that of adult typical dimyarian Pelecypoda,[2] Pl. XXV, fig. 9, where the hinge is dorsal, free edges of the valves ventral, the mouth and anus lying at either end of the equal valves, so that the antero-posterior axis[3] is nearly parallel to the hinge axis. In the adult oyster, Pl. XXV, fig. 12, this relation is different. The mouth lies close up under the hinge line, marking this as the anterior end of the shell. The free ends of the valves are at the posterior extremity, the gills lie on the ventral side, and the intestine on the dorsal.[4] The antero-posterior axis passes nearly through the umbos and centre of the valves and at an angle of about ninety degrees from the hinge axis.

To bring about the adult condition the antero-posterior axis has therefore revolved through an angle of about 45° from the position it had in the dimyarian stage. In this revolution the anterior adductor has disappeared and the posterior adductor has become sub-central, thus occupying the functionally most effectual position. In other monomyarians, as Pecten and Anomia, Pl. XXIX, figs. 1–2, the mouth closely underlies the umbos, which are in the median plane of the shell; thus the relations of the antero-posterior axis to the shell are similar to those of Ostrea.

In heteromyarians, as Mytilus, Modiola, Pl. XXV, fig. 10, Perna, Pl. XXV, fig. 11, and Avicula, a transitional series may be studied in which the relations of the axes are changed from what exists in the typical dimyarians, such as Mya, Pl. XXV, fig. 9, to what we find in the single-muscled group, as Ostrea, Pl. XXV, fig. 12.

In the clam, *Mya arenaria*, fig. 9, the adductor muscles are at either end of the longer axis of the shell, the mouth lies close behind the anterior adductor, the anus overlies the posterior muscle and the umbos lie dorsally. The antero-posterior axis is nearly parallel to the hinge axis. It is seen that in Modiola, Pl. XXV, fig. 10, the mouth and anterior adductor have revolved dorsally, so that they lie nearer to the umbos than in the clam. Similarly the posterior adductor and anus have revolved in the opposite direction, and occupy a position much farther removed from the hinge line than in the clam. The antero-posterior axis lies at an angle of about 25° from the hinge axis. In *Perna ephippium*, Pl. XXV, fig. 11, the mouth lies close up under the umbos, but the umbos are not in the median plane of the shell. No anterior adductor was found, but it probably exists in closely related species.[5] The posterior adductor and anus are still further re-

[1]The hinge axis refers to an ideal line drawn through the hinge area, and coinciding with the axis of motion of the valves, as shown in Pl. XXV, figs. 9–12, inclusive.

[2]I say resembles because the mouth does not closely underlie the anterior adductor muscle, as the velum intervenes, and therefore the comparison is not exact, though to all intents and purposes the comparison is perfectly correct.

[3]The antero-posterior axis, as shown in Pl. XXV, figs. 9–12, is considered as passing through the mouth and middle of the posterior adductor muscle and nearly or quite coinciding with the termination of the intestine.

[4]The fact that the umbos in the oyster are at the anterior end of the body has already been pointed out by several authors, and Hyatt (28) figures an oyster drawn over a clam to show their relations. Ryder (63), on page 787, notes the rotation of nearly ninety degrees that must take place from my fig. 25, p. 300, after Huxley, to bring about the adult relation of parts.

[5]Mr. Purdie, of New Zealand, notes that *Mytilus latus* has no anterior adductor, while two otherwise closely related species *M. edulis*, and *M. magellanicus*, have anterior adductors. In *M latus* the loss of the anterior muscle is accompanied by a movement of the one existing muscle inwards, nearer the central plane of the valves, where its mechanical action is more effectual.

moved from the hinge line than was the case with Modiola, and the antero-posterior axis lies at an angle of about 50° from the hinge axis.

A revolution of the axes similar to that traced in oysters, and in the above serial groups, may be seen in *Mulleria lobata*, Pl. XXVI, figs. 5–7, a widely separate genus. According to Adams and other authors, it has two muscles when young; but, when fully grown, one muscle. The anterior muscle has disappeared, and the posterior, which is retained, lies in the middle lower portion of the shell, in a position closely similar to that of an oyster. This case is particularly interesting, as the change takes place much later than in the oyster; for the two-muscled stage is not an embryonic one, but is of a much later period of development. In Ætheria, a near ally, the two muscles are retained throughout life, in a partially revolved position. Tridacna is another genus having but a single adductor muscle in the adult, and that muscle is the posterior. According to Woodward's figure the single muscle is in a sub-central position and the posterior retractor of the foot occupies its common point of insertion close to the dorsal aspect of the adductor. The mouth and palps have revolved dorsally so that they lie close up under the umbos as in Ostrea, marking this as the anterior end of the valves, and a large byssus by which the animal is attached is protruded through a notch in the valves immediately below the umbos. The antero-posterior axis lies nearly perpendicularly through the umbos and middle of the valves. The revolved position of the axes of the soft parts in Tridacna is not accompanied by any marked changes in the form of the shell excepting the position of the byssal notch. Allies of Tridacna are typical dimyarians and it is doubtless dimyarian when young.

The theory of the revolution of the axes explains the changed position of the axes and adductor muscles on purely mechanical grounds. It is found in widely separate genera of Pelecypoda that the revolving of the axes is accompanied by a reduction and final loss of the anterior adductor as it moves into a position close to the hinge area where its mechanical action is slightly if at all effectual in closing the valves. At the same time the single posterior adductor increases in size as it moves into a sub-central position where its action is most effectual. The revolution of the axes in Pelecypods, relatively to the axis (hinge) of motion of the valves, is therefore seen to be closely correlated with the reduction and final loss of the anterior adductor, together with the increase and final exclusive retention of the posterior. This theory substantially as here presented was published in my preliminary paper. While that paper was in press, a paper was published by Dr. Benjamin Sharp in which he presents a mechanical theory for the loss of the anterior and retention of the posterior adductor muscle in Pelecypoda, which is quite similar to that of the revolution of the axes.

It is a very noticeable fact that oyster spats attached to various foreign bodies do not lie with their axes arranged in any special direction. Different individuals attached to the same stone or shell, may have their axes at every angle of deviation, in the plane of the surface of attachment, as compared with one another. I have never seen them arranged with any reference to the resistance of prevailing currents. On the other hand, Anomias and Crepidulas are sensitive to prevailing currents. Large numbers of Anomias, attached to a single block, will very commonly be found with their axes parallel and headed one way (see discussion on development of Anomia, section XIII), and Crepi-

dulas, Pl. XXIII, fig. 22, may be found piled on one another to the height of several inches, each individual with its axes in the same vertical plane. These comparisons go to prove what was claimed earlier, that calcareous fixation of the oyster's lower valve took place when it became attached. It is almost certain that if any form of prehensile attachment had existed for an appreciable time, we should at least occasionally find evidence of the arrangement of the shells in the line of least resistance to currents.

VI. Ostrea. Development of the shell.

In the study of the soft parts it is shown that the shell of the oyster develops from a primitive structure, the preconchylian gland, which is found not only in other genera of Pelecypoda, but in other classes of mollusca as well. According to Horst, a simple unpaired-cuticular membrane, my fig. 22, p. 297, the product of the cells of the shell-gland precedes the paired calcareous shell.

The two valves of an adult oyster are together homologous with the single valve of adult Cephalous molluses (see p. 281). In both, the shell originated from similar structures, one as a single and the other as a paired organ. The adult shell of Cephalous mollusca is termed a conch. Therefore, in view of its homology and strikingly different double character, I have suggested (36) the name dissoconch[1] for the shell of an adult oyster and similarly the same terminology is applicable to the shell of other Pelecypoda.

The protoconch of Professor Owen, in Cephalopods, figs. 1–8, p. 292 and Pl. XXIII, figs. 15–16, is the early cup-shaped shell which precedes the conch, or true shell. A spirally twisted protoconch in Gasteropods,[2] Pl. XXIII, figs. 19, 21, 23, and a saddle-shaped periconch (protoconch) in Scaphopods, Pl. XXIII, figs. 13–14, may be also found as an embryonic shell preceding the conch or true shell of these groups (see section III). It will be seen from the study of Ostrea that the true shell, that which characterizes the adult, originates with the introduction of the spat stage, Pl. XXIV, figs. 19–21 and Pl. XXV, figs. 1–7. The earlier shell, Pl. XXIV, figs. 17–18, is strikingly different. It is the completed shell of the embryonic stages, and as shown in previous studies, it has developed from structures closely similar to those found in Cephalous molluses. The embryonic shell of Ostrea, therefore, is distinctly the homologue of the protoconch and periconch. In the oyster, however, this shell is not single- but double-valved and, therefore, deserves a distinct name. As it precedes the dissoconch or true shell, I have suggested (36) the name prodissoconch[3] or early, double shell, for the first-formed shell of the oyster. A prodissoconch or embryonic shell, strikingly different from the succeeding dissoconch, is figured in this paper in many widely separate genera of Pelecypoda (see Pls. XXIV to XXX and cuts in the text) and it may be safely considered as characteristic of the class.

The shell of oysters, at different periods of growth, presents striking dissimilarities. There are four well-marked stages of growth: (1) phylembryo, early embryonic stage; equivalvular, with a straight hinge line; (2) completed prodissoconch, symmetrical fry stage, with a curved hinge line and high umbos developed; (3) nepionic (spat) stage,

[1] *Δισσός*, double; *Κόγχη*, shell.

[2] See footnote, p. 292, and discussions in section on Classification of Stages of Growth and Decline.

[3] *Πρό*, before.

with a flat, lower left valve and convex, upper right valve; (4) adult, flat, upper right valve and concave, lower left valve.

The early prodissoconch or phylembryonic stage of *Ostrea edulis* is equivalvular, nearly discoidal and flattened into a straight line at the hinge area. On the hinge line, minute interlocking teeth are visible when viewed from the dorsal side. Embryonic shells of *Ostrea edulis* of this stage are represented in Pl. XXIV, figs. 13–16. They were removed from the gills of the parent and sent out as preparations by a London dealer in microscopical supplies. The age is similar to fig. 25, p. 300. The valves are saucer-shaped, and are marked by concentric lines of growth closely approximated dorsally, but farther apart ventrally and anteriorly, so that the centres of calcification are already pushed posteriorly by the growth that has taken place, as seen in figs. 13 and 15, viewed from the left and right sides respectively. By polarized light the shell gives the characteristic lines of crystallized carbonate of lime. A straight hinge line seems to be characteristic of the phylembryonic stage of Pelecypoda before the development of umbos (see section XV). As examples, I would refer to embryos of Ostrea, Pl. XXIV, figs. 13–16, Anodon, Cardium, Modiolaria and Montacuta, Pl. XXIII, figs. 7–11, also to Hatschek's figs. 19–21 of developing Teredo and Ryder's (62) figure of an embryonic *Ostrea virginiana*.

The valves of the phylembryonic stage of *Ostrea edulis*, Pl. XXIV, figs. 13–16, have scarcely any umbos developed, whereas our next stage of shell development has prominent umbos. The completed prodissoconch of *Ostrea virginiana*, Pl. XXIV, figs. 17–18, has deeply concave valves which are nearly equal. The lower left valve is, however, somewhat larger and deeper than the upper right valve, fig. 18. The umbos are highly developed and are always inclined upward at a high angle, as the shell is invariably attached by the extreme border of the left valve. The umbos are directed posteriorly as shown in the studies of the soft parts, Pl. XXIV, figs. 1–2, and they invariably point to the left of the observer viewing them from above, a necessary consequence of their being attached by the left valve.[1] (For further discussion of the fixation of the oyster by the left valve, see section IV.) Coincident with the development of high umbos, the early straight hinge line, seen in the phylembryonic stage, is lost and is superseded by one of a gentle curvature. The prodissoconch is the completed shell of the embryonic free-swimming veliger period, and the young oyster becomes attached permanently at the close of this period, the fixation consisting of the soldering of the ventral margin of the left valve to the object of support.

FIG. 26. Completed prodissoconch of *Ostrea edulis*, attached by border of left valve in an almost upright position (after Horst).

The completed prodissoconch of *Ostrea edulis*, fig. 26, differs from that of our species, according to Horst. The umbos are less developed than in our species, but they are directed posteriorly. Teeth, also, are mentioned on the hinge line at this stage and earlier by both Horst and Lacaze-Duthiers, whereas in our species no teeth have been observed by either Ryder (63) or myself. The histological structure of the shell, as described by Huxley and Horst, is similar to that of our species. Specimens of *Ostrea edulis* kindly sent to me by Dr. Horst show unmistakably the teeth and other features described.

[1] Professor Ryder informs me by letter that he has never seen an exception to this nor have I, though I have sought for umbos pointing to the right.

The prodissoconch of *Ostrea virginiana* is homogeneous and laminar in arrangement, "not prismatic" as in the immediately succeeding stages of spat growth as described and figured by Ryder (62). It is composed of lime infiltrating an amorphous matrix of conchyolin, as shown by treatment with acid. One of the marked characters of the prodissoconch is the uniformity of shape and size found in different individuals, it not having the ostrean tendency to variability noticeable in later stages. The height of the fully developed prodissoconch is about $\frac{1}{90}$ of an inch. The left attached valve turned over and viewed from the lower side is seen to be exactly like the right free valve in appearance. It is not flattened nor are there other indications to mark where it was attached, so that this attachment is evidently of a very superficial and delicate nature.

A prodissoconch identical, or very closely similar, to that found in *Ostrea virginiana* has been found in many species of the Ostreadæ. Ryder (62) has observed it in four species: *Ostrea equestris*, Say, from Florida; *O. conchaphila*, California; *O. cucullata*, Viti Islands, Pacific; and *O. peruviana*, Peru. I have observed it in undetermined oyster spats, from Cuba, and from the chamber of a *Nautilus pompilius*, from the Pacific. I also found ostrean prodissoconchs in the following: the spats of tertiary oysters from Carolina; *Gryphæa vesicularis*, Lam., Cretaceous, found in both European and American specimens; *G. calceola*, var. *nebrascensis*, M. & H., Pl. XXIV, figs. 23–24, from the Jurassic of Wyoming Territory, specimen number, 1881, U. S. National Museum; *Exogyra conica*, Cretaceous, Europe; *E. columba*, Lam., Cretaceous, Europe; *E. arietina*, Cretaceous, America; and *E. costata*, Say, Cretaceous, America. Of this last species abundant very young specimens, which I collected at Delaware City, Delaware, showed the typical early prodissoconch.

From the number and wide distribution of the species, it cannot be doubted that the prodissoconch found in *Ostrea virginiana* is characteristic of the Ostreadæ. The teeth noted above in the prodissoconch of *O. edulis* is the most striking difference that has been found in the prodissoconch of the family.

There is, in the prodissoconch and spat stages of the oyster, an organic conchyolin attachment of the shell itself, thus described by Ryder (62): "The cementing material seems to be the organic matrix of the shell which forms a perceptible layer on the outside of the valves, and which constitutes the epidermis or periostracum of the oyster." In the prodissoconch, as well as spat stage, the cement is so firm that, as Ryder says (62), the shell may be broken before it can be removed. To prove that this is an organic cement, if we put a drop of water on a dead, young shell and allow it to remain a short time, it can be readily picked up on the point of a knife. Quite large spat may be removed when dead (*i. e.*, the organic matter inert) by soaking or boiling. Treatment with acid, on the other hand, does not loosen the hold of the shell. Quantities of young spat die during the summer, yet few dead shells are found on cultch, because soon after death the organic cement decays, is dissolved, and the shell falls off. Professor Huxley notes that the European oyster separates naturally from unfavorable objects of support; and that the separation takes place naturally at an early stage can be seen markedly in many fossil members of the family. Conversely, the calcareous plug of Anomia, which is fixed to the object of support by a purely calcareous union, remains indefinitely after the death and separation of the individual to which it belonged. All the evidence is there-

fore in favor of the assumption that the cement by which the oyster is attached is wholly organic.

With the introduction of the spat stage, a fundamental histological difference arises abruptly in the structure of the shell of *Ostrea virginiana* as in *O. edulis*, fig. 27. As stated above, the prodissoconch consists of lime infiltrating an amorphous matrix of conchyolin, but in the initial spat stage the first layer of shell of the right valve is deposited in a "tessellated or prismatic" manner in a horny matrix, as described and figured by Professor Ryder (62, 64). Soon after the formation of the spat stage, the subnacreous, white porcellanous layer begins to be deposited on the yellowish-brown, prismatic layer, first making its appearance as irregular blotches in the centre of the valves. These two layers continue throughout the rest of the life of the oyster, and together, though in disproportionate degree, build up the massive adult shell. The prismatic layer always remains thin, as may be readily seen by sections, or by treating an adult with acid, when the remaining conchyolin of the prismatic layer will separate from the overlying subnacreous layer like a dissected skin.

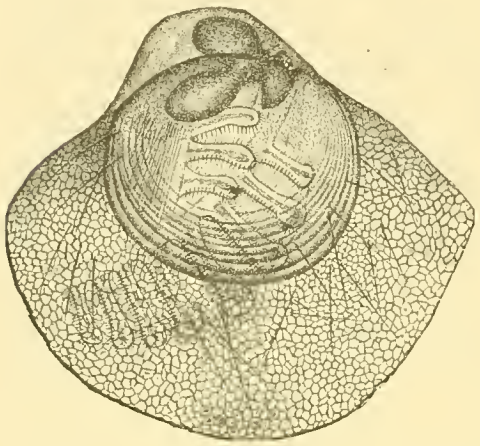


Fig. 27.

Fig. 28.

Fig. 29.

Fig. 27. Young *Ostrea edulis*. The prodissoconch is composed of homogeneous and the early dissoconch of prismatic cellular tissue.[1] The gills are filamentous.

Fig. 28. Fragment of border of upper valve, enlarged to show the prismatic structure.

Fig. 29. Fragment of lower valve (after Horst).

It is a remarkable fact that in young *Ostrea virginiana* the prismatic structure is typical of the upper right valve alone; the lower valve presenting a fine granular structure, as in *O. edulis*, fig. 29. In later life in *Ostrea virginiana* and some other species, a very thin layer of prismatic tissue may be found in the left valve though it is for the most part eroded away, but the same layer is thicker and therefore better preserved in the right valve. The prisms of the right valve of the adult oyster are not as perpendicular to the surface as in the young, fig. 27. Therefore in horizontal section the outline of the prisms presents oblique rather than hexagonal faces. A similar obliquity of the prisms may be seen in *Solemya mediterranea*.

The nepionic or infant stages of molluscs begin according to the classification of stages adopted with the formation of what Professor Owen called the apex of the conch, or true shell. It is shown that the spat marks the beginning of the dissoconch (true shell) in Ostrea; therefore the spat is considered as the nepionic period.[2] In my preliminary paper I said the spat of *Ostrea virginiana* is divisible into five stages which were described at some length. I also said that they are more or less clearly marked in every

[1] The relations of structure of the prodissoconch and dissoconch are the same in *Ostrea virginiana*, also in Perna, Pecten and Anomia, as described in the text.

[2] In my preliminary paper this same period was considered as the "silphologic" period. In a footnote to this paper Professor Hyatt has given up the use of the term silphologic, and has supplied in place of it the term nepionic (*vide* p. 290).

regular growing, unworn, young specimen. There are often well defined stages indicated as arrests of growth in the early growth of the spat; but I must retract the statement that there are typically five and that they are always more or less clearly marked in regular, unworn, young specimens. Frequently no indication of later spat stages are present, and they cannot be considered as constant. To remodel my conclusions and statement: The spat stage in *Ostrea virginiana*, as a whole, is frequently marked by stages of growth. Stages are characteristic of the earliest spat growth and as many as five have been found, but often no more than two or three are indicated. To study these stages specimens should be sought growing in protected places, as the wear of sand and waves destroys their demarcation rapidly. Some spat found in the inside whorls of dead Sycotopus shells and others, secured on glass in drain pipes and on inverted flower pots, retained the markings clearly.

The spat growth begins along the ventral margin of the prodissoconch valves Pl. XXIV, figs. 18–21 and Pl. XXV, figs. 3–4, and throughout life the most rapid growth is in this direction. The growth rapidly pushes up the sides of the valves, and between the hinge areas of the latter, Pl. XXV, fig. 3, lifting them apart and separating them by interstitial growth. A little to the right of the umbo of the lower, left prodissoconch valve, as seen from above, in the initial stages of spat growth, is a notch which indicates the beginning of the cartilage pit of the lower valve. This is seen clearly in Pl. XXIV, fig. 19. It is necessary to describe the left and right valves separately. The upper, right valve, Pl. XXIV, fig. 20, is continuous with the prodissoconch valve and follows the curve of that stage though in a lessening degree. It spreads out laterally on the hinge line in a descending curve, and on the margin overhangs the lower valve by a considerable amount, Pl. XXIV, fig. 21, as it continues to do while the shell is flatly related to the object of fixation. The same overhanging of the upper valve may be seen in young Pectens, Pl. XXVIII, and Anomias, Pl. XXIX. The lower left valve of the young oyster, Pl. XXIV, fig. 21, starts as does the upper, following the curve of the early valve. When this curve has been followed for an extremely brief period, the valve suddenly flattens and becomes closely related to the surface of attachment. The result is, that a slight groove runs around the border of the spat valve, beyond which it is abruptly continuous with the flat later growth as mentioned by Ryder. I have, however, to note a peculiar and significant exception. Sometimes, instead of becoming flat and closely related to the object of attachment, the spat valve is continuously curved throughout its early growth, and not at all flattened. It then resembles the upper valve in shape. This curved shape is held, as far as observed, only on rough objects of attachment. Seeking for such material on rough stones and shells, one will always find some valves more or less curved in their earliest stages. This is interesting, as showing the modifying influences of environment on a very young stage, where heredity might be supposed to fashion the form with overpowering force. Further notes on this character are given when discussing Exogyra, section VII.

When the spat shell has attained the height of 0.8 mm. to 1.2 mm., frequently a well defined stage or period of growth is marked by an interruption in the lines of growth as shown in Pl. XXV, figs. 1–2. This indicates what is considered as the close of the first nepionic stage. In the shell growth succeeding the first nepionic stage the upper valve,

fig. 1, is in form a continuation of the first stage. The lower valve spreads out over the object of attachment by wing-like extensions of its anterior margins, and makes a shoulder on its anterior border by its increased growth, where it comes in contact with the outer limit of the first stage, fig. 2, and similar shoulders mark the periods of growth of later stages in the lower valve, Pl. xxv, fig. 6. The lower valve may remain curved, as in the first nepionic stage, for a limited extent. When the spat has attained the height of from about 1.4 mm. to 2.4 mm., another stage is frequently marked by an interruption in the shell growth as shown in Pl. xxv, figs. 1–2, which illustrate the first and second stages of the nepionic or spat growth. After the second stage, as described, other stages may be found in the spat growth. They are marked as arrests in the regularity of shell growth and in the lower valve shoulders are formed by their contact with earlier stages as shown on the hinge border in Pl. xxv, fig. 2. In all, five stages have been observed; but the number and the later stages cannot be considered as characteristic as the first two stages are.

After the close of the second spat stage the shell is still even and rounded in outline, as the convolutions and distortions common in oysters do not often begin till growth has considerably advanced. The lower valve spreads out over the object of attachment, and leaf-like layers of shell deposition may be seen spreading beyond the limits of the hinge line, as growth continues, as shown in Pl. xxiv, fig. 19, and Pl. xxv, fig. 5. The upper valve in regular growing specimens frequently departs from the form which is observed in the earlier growth, Pl. xxiv, fig. 20, and spreading out laterally becomes more wing-like on the margin than in any earlier stages, Pl. xxv, figs. 5 and 7. These wing-like productions of the spat growth were pointed out and figured by Ryder (60). In describing such stages he says: they are " . . . . handsomely rounded in shape, not unlike a scallop in form, which they simulate still more by the lobes which they develop on the shell on either side of the hinge." This scallop-like form, shown in Pl. xxv, fig. 7, is quite likely due to the irritating action of a foreign body on the extended mantle border of the left valve, or it may be due to the opportunity to make more secure the fixation by deposition of lime in this direction. In spat growth the free ends of the valves often change the direction of their growth to the left or right of the median line. By this change the umbos may be revolved so that they often point in the opposite direction from that which they would have otherwise assumed, as noted by Ryder (65). A twist in the direction of growth as described is characteristic of the fossil genera, Exogyra and Gryphæa, in which the variation is always to the left of the median line viewed from above. The young oyster when it twists to the left resembles very much a young Exogyra; but when the twist occurs in the opposite direction, or to the right, as frequently occurs, this close comparison cannot be made. The right valve of the spat has a sinuosity, *si*, Pl. xxv, fig. 5, which is related to the excurrent flow of effete water as described, p. 307.

Throughout the period of spat growth the young oyster shell has an approach to the rotundity characteristic of the early spat stages. The attached valve is flat and the free convex, but when the oyster projects beyond the object of fixation this relative form of the valves is changed and the condition characteristic of the adult, Pl. xxv, fig. 8, is brought about. The attached valve becomes deeply concave or spoon-shaped and the free valve conversely becomes flat, as pointed out by Brooks and Ryder. At the close

of the spat period if the shell does not project freely from the object of fixation, then the relative shape of the valves characteristic of the spat is retained, the attached valve still spreading over the support, is flat, and the free valve is convex. In such forms the true spat period is marked as a smooth rounded convex area at the umbos.

In young *Ostrea virginiana* spat, as noted by Ryder (60), bands of purple color radiate from the hinge line, widening toward the free edges of the valves; but these coloration bands are in the prismatic layer and are therefore limited to the upper right valve. In none of the oysters growing on glass, have I seen color bands in the lower valve, which is nearly or quite white; in later growth, however, faint traces of color bands may be occasionally seen in the left valve. I found spat in the living chamber of a *Nautilus Pompilius*, when unpacked on arrival from Singapore, and these are similar to the spat of *O. virginiana*, showing similar prodissoconchs and nepionic stages, but no coloration bands, the upper valve being yellowish-white. The early spat growth of *Ostrea edulis*, fig. 27, p. 314, is very similar in form to that of *O. virginiana*, Pl. XXIV, fig. 20, but I have not had specimens for a comparison of later stages.

VII. Gryphæa, Exogyra and Adult Ostrea, with a Consideration of the Mechanical Origin of the Ostrean Form of Shell.

The genus Gryphæa is described as free or attached in the young, yet I have not been able to find a species in which it is free at a very young stage. All the species studied have a flat area in the lower valve and a curved area in the upper valve at the umbos, corresponding to the condition found in the attached spat stage of the oyster. *G. arcuata* of the Lias is commonly considered as free, yet I have found well preserved specimens, Pl. XXIV, fig. 22, in which the lower valve is flat at the apex, where it was attached when young, and correspondingly the upper valve has a small convex area at the umbo, as noted by Sowerby. Flat areas of attachment have also been found at the umbos of two other highly arcuate species, namely, *G. calceola*, var. *nebrascensis*, M. & H., Pl. XXIV, figs. 23–24, from the Jurassic of this country, and *G. pitcheri*, Morton, from the Cretaceous of Texas.

The area of attachment in many species of Gryphæa is uniform in size, indicating that the shell dehisced at a very definite period from the object of attachment. In fact, highly arcuate forms must have separated early, as the involute form could not have been developed unless the shell was free. Other species were attached for a very variable period, as is seen by the differing size of the flat area of the lower valve and corresponding curved area of the upper. This is well shown in any large collection of the European form of *Gryphæa vesicularis* from the Cretaceous, where the arcuateness of the adult varies inversely as the length of period of attachment.

Exogyra, also, is said to have been free or attached; but here the case is somewhat more complex. Take, for example, the typical *E. costata*, Say, of the Cretaceous. Specimens are found in which a flat area at the apex of lower valve distinctly shows them to have been attached when young, but rarely are adults found with the object of early fixation still clinging to them, showing that as in Gryphæa and many oysters, they separated naturally. Other specimens are found which, upon most careful examination, show no

flattened area on the lower valve. I have noted that Ostrea may in its early nepionic period be attached, and yet not conform to the object, or become flattened at all, so that if it could have separated at the close of this period, the adult would show no sign of early fixation. This is what apparently took place in specimens of Exogyra which show no flat area. In such there is no proof that they were not fixed during the young stages, but merely that they dehisced before the shell conformed to the outline of the object of support. Some individuals may be attached for a considerable extent, and a specimen in the American Museum in New York has an area of attachment measuring 11 cm. in its greatest length. This species is also very variable in the degree of costation. Aged specimens, as noted and figured by Whitfield, often lose the ridges and become quite smooth. I have seen many specimens in which the lower valve was first smooth, then costate, and later smooth again, or the reverse of this order. In a large collection one may find every gradation between the highly costate type, known as *Exogyra costata*, and the smooth type without costations known as *E. ponderosa*, Roemer. The relations of these species is about the same as that which exists between *Ostrea virginiana*, Lister, and *O. borealis*, Lam., which Verrill unites under the former species, as he says they may easily be connected by all sorts of intermediate forms.

In the Ostreadæ there is a striking peculiarity of the adult which has not been considered in its full significance, so far as I am aware. *The two valves are unequal, one being concave and the other flat; but they are not only unequal, they are very dissimilar, as different as if they belonged to distinct species in what would be considered typical forms.* This character of the shell is due, I believe, to the mechanical conditions of direct cemented fixation acting upon a Pelecypod shell, and is of great value in considering the systematic relations of attached groups as I shall attempt to show in the following pages.

As examples amongst the Ostreadæ, showing dissimilarity of the two valves, we may take *Ostrea edulis* of Europe, *O. compressirostris*, from the Eocene of this country, and *Exogyra costata*, from the Cretaceous. In these species the lower valve is plicated, and the upper smooth, and regular-growing, without plications. The examples could be multiplied extensively, but these suffice to give my meaning. In consulting Coquand's finely illustrated monograph of Cretaceous oysters, examples of this difference of the two valves will be found in many species. This is a highly interesting feature, as it is a *case of inherited or acquired characteristics, finding very different expression in the two valves of a group belonging to a class typically equivalvular.* As might be expected, variations from the rule are occasional as in *Ostrea marshii*, *O. larva*, etc., where the two valves are more closely alike. Dissimilarity is nevertheless the rule. The upper valve may bear characteristic features not found in the lower valve. As an example we may mention *Gryphæa vesicularis* of the Cretaceous, in which the upper valve in both European and American specimens is marked by radiating depressed lines. Similar radiating lines may be found in *G. dilatata* from the Jurassic, and indications of them have been observed in other species. These lines are a feature which would probably be of value in tracing the serial connections of the several species possessing them.

The differences in the two valves may be observed in species of Spondyli, especially those in which the right, attached valve is very ostreaform, while the free, left valve is

less modified, as shown in *Spondylus hippuritarum*, d'Orb., Pl. XXVI, fig. 1. We would also refer the reader to M. d'Orbigny's plates 450 to 461 of Cretaceous Spondyli, especial attention being called to his figures of *S. histrix*, Goldf., in which the attached valve is rough and ostreaform, whereas the free valve is evenly plicated and smoother. Striking differences in the features of the two valves may be seen in the Rudistæ as shown in *Radiolites fleuriausa*, d'Orb., Pl. XXVI, figs. 11–12, in which the lower attached valve is irregularly cornucopia-shaped, whereas the upper free valve is comparatively regular growing, flattish and plicated. The young of this species and several species of Hippurites studied resemble an Exogyra (compare the figures cited with the adult and young of *Caprotina semistriata*, Pl. XXVI, figs. 10 and 20). Because the young of these aberrant forms resemble an Exogyra, I do not wish to imply any genetic connection with that group. I state later, p. 322, the conviction that the ostrean form is induced by the condition of fixation, and the similarity to an Exogyra in the young of the Rudistæ and Chamidæ is believed to be due to the similar conditions of a fixed cemented habit common to both groups, and not as expressing any affinities. This is a point which must be understood, as in this paper high importance is attached to the form of young shells in tracing genetic relations.

Aberrant forms of the Chamidæ are shells which show in a high degree differences in the attached and free valves. *Caprinula boissyi*, d'Orb., Pl. XXVI, fig. 8, from the Cretaceous of Europe is a remarkable form; the attached valve is deeply conical with perpendicular rugæ ,whereas the free valve is spirally twisted, without plications and resembles a typical Diceras. *Caprotina semistriata*, d'Orb., Pl. XXVI, fig. 10, is another form not less remarkable in the striking dissimilarity of the two valves. In this species the attached valve is arcuately conical with perpendicular rugæ and showing at its base a spirally twisted tip as in Radiolites, Pl. XXVI, fig. 12. The free valve is of a simple concave form, not at all aberrant and not presenting the rugæ seen in the attached valve. A very young specimen of *Caprotina semistriata*, Pl. XXVI, fig. 20, was found attached to the base of a colony of this species in a specimen in the Museum of Comparative Zoölogy. This young Caprotina resembles an Exogyra, taking for comparison a young *E. costata* or an adult *E. spiralis*, Goldf. The attached valve is highly twisted and the free valve convex showing little twisting as in Exogyras. The specimen was too much worn to show lines of growth, but in the figure they are inserted where I think they would appear if not eroded, in order to render the form and its relations to the adult clearer. That they are fairly represented will be evident upon a comparison with similarly twisted shells where they arepreserved. As the attached valve in Caprotina, Pl. XXVI, fig. 20, grows from its early twisted condition to the deeply conical condition found in the adult, Pl. XXVI, fig. 10, the lines of growth gradually and progressively assume a more and more horizontal position until in the adult they are nearly or quite horizontal and the attached valve has lost the twisted condition characteristic of the younger stages. The outgrowth from an early twisted condition of the attached valve to an adult deeply conical condition, as just described, doubtless took place in the development of *Caprinula boissyi*, Pl. XXVI, fig. 8, and the change may be seen in *Monopleura marcida*, White, Pl. XXVI, fig. 9. In Dr. White's paper (74) the same feature and the modification of attached shells are very well shown in many species.

Our examples of differences in the two valves amongst attached Pelecypods might

be carried further and for such inquiry we would refer to published works on conchology and palæontology. Believing that the inequivalvularity of the above genera is due to the conditions of environment acting on a bivalve shell, I would refer to species of attached Brachiopods in which is found further proof of the correctness of the conclusion. *Davidsonella rugosa*, Pl. XXVI, figs. 14–15, the Cretaceous, is soldered to an object of support by the lower valve, and here, as in the above cases of Pelecypods, the attached valve, which is rugose and concave, is strikingly different from the upper valve which is flattish and smooth. The same feature is shown in species of *Strophalosia* recently discovered and shown me by Dr. Beecher. *Productus proboscideus* of the Carboniferous has a tubular highly modified attached valve and a nearly normal free valve[1].

In the various genera considered, *the free valve is that which is least modified and nearest resembles the form existing in both valves of less aberrant related genera. It is the attached, cemented valve, which is highly modified* and so much so as by itself in some cases to be with difficulty recognizable as belonging to the Pelecypods.

In the shell of *Ostrea virginiana*, Pl. XXVI, fig. 13, there are lenticular cavities in the hard subnacreous portion which are filled with a soft, white, chalky deposit. These cavities are also noticeable in many fossil oysters and Gryphæas. In Exogyras they are commonly very large and abundant, especially near the umbos where shell growth takes place rapidly and to a great thickness. *Exogyra costata* shows these cavities well, and they are highly developed in *Exogyra aquila*, Goldf. and *E. couloni*, d'Orb. from the Cretaceous of Europe. Not infrequently the cavities in living and fossil shells will be found filled with mud, and in such cases it is evident that the shell roofing was formed to include the mud; being caused by the irritating action of that substance on the overlying mantle. Specimens of *Mya arenaria*, which have included mud in this fashion are frequent, although this shell never builds true camerated structure. The shallow chambered structure of the oyster was noticed by Professor Owen (50, 51) and was compared by him to similar conditions in the shell of Spondylus, Ætheria and some univalves. Professor Woodward (77) compared the structure of the oyster also with camerated structure in species of Teredo and Caprinella which he figures. This last genus is remarkable for the regularity and size of its chambers which truly resemble analogous structures in Cephalopods. Owen (50) notes the fact that Spondylus and other bivalves, which have camerated structure, are cemented to extraneous bodies by the shell. I have not made an extensive study of this subject; but what has been made, leads to the conclusion, that this statement may be safely reversed and we may say, that *bivalves which are cemented by one valve to extraneous bodies have a tendency to produce a camerated structure of the shell* which is not found in free forms. Thin shelled, cemented Pelecypoda, such as Dimya, quite likely would not show cameration, but amongst other groups it is general, whereas no free lococomotive forms of Pelecypods, however thick the shells, have been found to possess such structure.[2]

[1] In the developing shell of *Vermetus radicula*, fig. 9, p. 294, I have observed in well-preserved specimens that the shell is evenly spiral and regular growing while young and unattached. As soon as attached, however, the irregular loosely spiral features characteristic of the adult are introduced and are retained throughout subsequent growth.

[2] It is important to notice that fossil corals of the Tetracorolla type have a highly developed camerated structure. So similar is their appearance in their regular chambering that they may often be compared to chambered Cephalopods especially of the Cyrtoceras type which they simulate by their arcuate form. They also bear often a striking resemblance both in external and internal form to

In adult *Ostrea virginiana*, the left valve is concave, and the right flat, when growing naturally, the left valve being lowermost; and Ryder notes that the same relative shape is held by oysters which grow vertically in crowded beds. Oysters frequently attach themselves to the lower side of objects, so that the left valve is uppermost, and right valve lowermost, the reverse of the common position, Pl. XXV, fig. 8, and here again the normal relative shape of the valves is maintained, the left valve concave, the right flat. The shell of the oyster is so variable that we should expect it to be especially susceptible to varying conditions of environment; yet these strikingly different positions produce no change in the resulting form. Whatever the cause of the typical form of the group, the changed relations brought about by inversion, or other positions assumed by the growing valves, are insufficient to modify greatly the form of a modern individual, where hereditary or other influences bind the shell within the limits of its typical form.

Professor Hyatt (29) has published the view that the *attached supported* valve of fixed bivalve shells is the larger, the element of gravity being the active factor according to his ideas, and he ascribes the form of the oyster and similar shells to such conditions of environment. My conclusions on the form of attached Pelecypod shells, although somewhat similar, differ from those of Professor Hyatt. The conclusions, as presented in these pages, are that the form of fixed Pelecypoda is due to the conditon of *cemented fixation;* whereas his assume that the form of inequivalvular bivalves is due to *support*, the shell being free or not as the case may be. The two views are therefore based on different grounds of consideration, which should be borne in mind in a comparison of our studies.

The family of the Ostreadæ is characterized throughout by being attached, at least when young, by the left valve, as shown in Pl. XXV, fig. 8, and Pl. XXVI, fig. 13. The left attached valve is typically, deeply concave, of rough, irregular growth and comparatively thick. The right free valve, on the other hand, is flat or flattish, thinner, and less irregular. To perceive the truth of this statement it is necessary to look over a collection of the Ostreadæ, or in default of it some of the illustrated monographs, as Coquand's or White's. It will then be seen that all typical forms are referable to this description in a more or less marked degree. I say more or less marked, because some species, especially among the Alectryonia division, have right (free) valves which are comparatively like the left valves; but on careful study one finds that it is only a matter of degree and that they are actually less concave and generally less irregular than are the left attached valves.

The systematic position of the family to which the oyster belongs has long been a perplexing problem to the naturalist; the asymmetry and irregularity of the valves has rendered them a group difficult to characterize and of uncertain systematic position. The late Mr. Tryon in his work on Conchology says: "The union of the Ostreidæ

the attached valve of Hippurites. *Calceola sandalina*, an operculated coral, has a deep thick attached valve and flattish thinner free valve; bearing thus considerable analogy to the effects produced in bivalve molluscs by cementation. Beatricea, a fossil of uncertain affinities, has well-marked camerated structure. In all these attached forms there is an irregularity of growth and cameration strongly recalling the similar structure induced in Pelecypods by the condition of cemented fixation. Woodward (77) suggested that septa and other forms of cameration in Molluscs are induced by the mechanical necessity of cutting off the rear unoccupied portions of the chamber of a shell as the animal is urged forward by the growth taking place on the free edges of the living chamber.

and Pectinidæ, as proposed by the authors of the 'History of British Mollusca,' has not proved satisfactory. The genus Ostrea stands quite alone, and distinct from all the Pectinidæ in the structure of its gills, which are like those of Avicula, and by resting on its left valve. The shell also is more nacreous than that of the scallops." Another leading naturalist, Dr. C. A. White, in a recently published monograph of the Ostreadæ of North America, says: "To what primary cause this asymmetry among the Ostreidæ is due, it is, with the present limitation of our knowledge, impossible to say; but it is certainly a characteristic of the whole family, including all its genera and its fossil as well as living forms."

My studies of the Ostreadae, and other Pelecypoda as well, have brought me to a conclusion in regard to the origin of the peculiar forms we have here to deal with, which is that the ostrean form is due to the *conditions of a direct cemented fixation, acting upon a Pelecypod shell.* Given such conditions, and a closely similar form is the result in widely separated genera of this class, as I shall attempt to show. The form which is claimed as the result of the conditions of direct, cemented fixation is a concave attached valve; a flatter free valve, commonly much thinner than the attached valve; an irregularity and asymmetry of growth tending to the displacement of characters normally found in near allies of the subject under consideration, and as a general thing a camerated structure of the shell. The fullest modification in this line of variation is the production of a shell in which the attached valve is cup-shaped, conical, or sub-cylindrical as seen markedly in the Chamidæ and Rudistæ. In this group all the transitions may be traced from a simple ostreaform or exogyriform shell to the most highly modified conical type. A further result of the modified condition induced by fixation and which I consider perhaps the most interesting of all, is the fact that the attached valve is the most highly modified; the free valve being the least modified and retaining more of the ancestral characteristics, *enabling one through it to trace the genetic connections of the group, evidences of which may be completely eradicated from the attached valve.* If the ostrean form is due to the conditions of direct fixation, then all or nearly all Pelecypoda which have one valve cemented to a foreign body for a longer or shorter time should be ostreaform or modified in this line of variation.[1] First, fixed forms will be considered as

[1]The Rudistæ are conical or cup-shaped Pelecypods with a superficially marked radial symmetry. So striking is the radial feature that they have been classed with the corals or Cirrhipeds, and the term radial is combined frequently in generic and specific names of the group. *Barretia monolifera*, described by Woodward (78), is highly radial, and infoldings of its thin walls closely resemble the radial septa of corals. In other animals which are permanently attached by calcareous fixation as corals, some worms, and Brachiopods, Cirrhipeds and others we find closely comparable forms in which radial symmetry is a marked feature. When similar forms are built up on different lines of descent, there is strong evidence that common forces acting on all alike have induced the resulting form.

I suggest the following as a possible explanation of the cause of these markedly similar forms, and would say that I have a great deal of evidence on the question but it must be reserved for a future publication. The equal impact of moving water on all sides of an attached growing organism it seems would cause an equal effort of resistance on all sides, and therefore induce an equal growth on all sides, thus producing a form circular in section at any one horizon and sub-conical, cup-shaped or globose in its entirety as are all the attached forms which we are considering. To strengthen the walls of a round organism, the wall might be thickened by solid accumulation, by vesicular formation or by perpendicular partitions arranged at right angles to the supported wall. Such mechanical supports are characteristic of attached Cœlenterates, Rudistæ, Cirrhipeds, and some Vermes. As all sides of the periphery of an attached organism are equally exposed to food-supply, danger, etc., the organs, as tentacles, nerve-centres and eyes, would gradually tend to become situated at all points on the periphery, or radially. It is well known that the external parts of an animal are more easily modified than the deeper-seated parts. It is also known that the modification of deeper-seated parts may be

proof of this fact and then special cases will be considered which show the relation of cause and effect.

The genus Spondylus is attached by the right valve. It has a concave right valve, flatter left and a highly developed camerated structure. The growth is irregular, spinous, uneven, and the lower valve is often highly ostreaform as shown in *Spondylus hippuritarum*, Pl. XXVI, fig. 1. The group is called spiny oysters from the typical spiny growth and ostrean form. In the Challenger Report, a species is described as *Spondylus ostreoides*, Smith, so named, on account of the close similarity to a small oyster, the features of comparison being marked in both valves. Plicatula, a genus nearly related to Spondylus and attached by the right valve, is also highly ostreaform. This genus, as is the case with the Ostreadæ, becomes attached at the close of the prodissoconch stage, as shown in Pl. XXVII, fig. 5, and the ostrean characters are assumed at that period of development.

The Chamidæ as a group are characterized by ostrean features, though departures in degree rather than in kind are seen in several genera. The genus Chama has typically a deep, irregular, thick, attached valve and flatter, thinner, free valve. A Tertiary species is named *Chama gryphœata*, on account of its close likeness to the genus Gryphæa. Chama constitutes one of the best proofs that the condition of fixation causes the form of the valves, because some species are attached indifferently by the right or left valve, and in both cases the resulting form is the same, a deep attached and a flatter free valve. *Chamostrea albida*, Pl. XXVI, fig. 2, which is attached by the right valve, is almost indistinguishable in external characteristics from many forms of Exogyra. The aberrant forms of the Chamidæ, as Caprinula, fig. 8, Monopleura, fig. 9, and Caprotina, fig. 10, Pl. XXVI, also similar allied genera, are forms which may be considered as extremes of variation due to fixation. The attached valves are deep and mostly cornucopia-shaped, often highly irregular and asymmetrical, whereas the free valves, though frequently modified, are yet not different from what is often met with in genera of unattached Pelecypods. In these peculiar genera it is the free less modified valves and extreme young to which we must turn in studying the relationships of the groups. In occasional species the attached valve is not deeper than the free valve, which is the larger and deeper of the two. Such forms are exceptional, as in all other

progressively produced from without inwards (example: development of internal from external skeletons in fishes), or *centripetally* as I would call it. To return, if we have an attached animal that is round, with some organs arranged on the periphery (a very common case), then further modification or development of such organs or parts would tend to be produced *centripetally or radially*, for the centripetal variation of a round form equally exposed to modification on all sides, would, as a mechanical necessity, be radial variation. In the Hydrozoa there is strong proof of the correctness of this view. Passing from Photohydra to Hydra, to the hydroid stage of Aurelia, then to the free medusoid stage of Aurelia and other Discophores, we find progressively a more and more perfect radial symmetry built up centripetally. Passing to free swimming Hydrozoa, as the Ctenophores, radial symmetry is eradicated, and an almost complete bilateral symmetry adopted by the adult. A similar line of comparison may be made in the development of corals. Cirrhipeds in the shell show a very complete radial symmetry especially seen in Coronula.

Many permanently attached forms of bilateral classes of animals assume a considerable degree of radial symmetry and, conversely, many free locomotive genera of radiated animals assume a considerable degree of bilateral symmetry. As bilaterality is a feature induced and progressively built up by the conditions of free locomotion, it is believed that radiality also is induced and progressively built up by the conditions of permanent fixation with its attendant influences of environment.

Many animals are attached by more or less fleshy processes from the body, as Brachiopods by a peduncle and Pelecypods by a byssus, but these do not adopt a round form, as do those groups which are attached by a more permanent calcareous fixation.

fixed Pelecypods that I know of, the normal condition of a deeper fixed valve is maintained. However, the relative size of the fixed and free valves is a factor, which may be subject to variations without impairing the general conclusions as to the effects of fixation.

The Rudistæ is a group having an enormously developed attached valve of highly irregular growth and a flattish free valve. The free valve may be of a form similar to that found in unattached normal Pelecypods, while the fixed valve is most irregular as shown in *Radiolites fleuriausa*, Pl. XXVI, figs. 11–12. Commonly, however, the free valve of the Rudistæ is radially plicated in the adult and differs widely from any normal form of Pelecypod shell. This extreme variation marked in both valves is accounted for as a case in which the conditions of fixation have produced the extremes of modification (see note, p. 322), affecting the free as well as the fixed valve, instead of the latter principally, as is the normal case.

Dimya is a genus of rare and little-known Pelecypods. The shell is irregular ostreaform and attached by the beak of the right valve which is deeper and larger than the other. We fail to see any important characters of anatomy (described in *D. argentea* by Dall) which would connect it closely with Ostrea to which it has been compared by writers. From my view, whatever the affinities, its ostrean form of shell is due to the conditions of fixation.

The Mulleriaceæ comprising the genera Mulleria, Ætheria and Bartlettia is a division of the Unionidæ, which in the adult condition resemble oysters. *Mulleria lobata*, Fer., is so remarkably like an oyster that it has been called the fresh-water oyster. In the Monomyarian adult, Pl. XXVI, fig. 5, the shell is rough and irregular, with a deep attached and flattish free valve, and a specimen in the Museum of Comparative Zoölogy is indistinguishable in shape from forms commonly found in *Ostrea virginiana*. The shell as in Ætheria, also has a finely camerated or blistered structure. The young shell of Mulleria, Pl. XXVI, figs. 6–7, is Anodon-shaped, equivalvular and dimyarian as described by authors. In this genus we have the important feature of an Anodon-shaped shell, losing its symmetry and becoming irregular and ostreaform as soon as attached.

Hinnites is an important genus in our considerations. In the young it is free and pecteniform, but in the adult is attached by the right valve, is irregular and more or less ostreaform. So close is the likeness to an oyster that in the synonymy of the genus it has been named Ostrea and Ostracites. *Hinnites cortesi*, Defr., Pl. XXVI, figs. 3–4, from the Tertiaries, illustrates clearly the characters found in the young and adult shell. We will consider the two valves separately. In the young nealogic period the right valve, fig. 3, is purely pecteniform. It has well developed ears, a deep byssal sinus, and an evenly plicated shell which at this stage is nearly or quite equivalvular. At a definitely marked period, as shown in the figure, the valve becomes attached to a foreign body by a cementing fixation of the shell. With this change in condition, a most marked change in form immediately takes place. The shell grows irregularly, losing the evenness and in considerable degree even the existence of the plications marking its nealogic period. While the early nealogic shell was but slightly concave and pecteniform the adult fixed valve is deeply concave and highly ostreaform. The byssal notch, which is a marked feature of the nealogic stage, is filled up and completely wiped out of existence by the irregular ostreaform growth. The left free valve, Pl. XXVI, fig. 4, in the nealogic stage,

is even and regularly pecteniform like the right valve. When the right valve becomes attached, the left valve affected somewhat by the same conditions loses much of the regularity and evenness of marking characterizing its nealogic period, but it never becomes as irregular in growth and ostreaform as does the right (attached) valve. Hinnites is marked therefore by a byssated pecteniform stage followed by an attached ostreaform stage. The transitions described in *Hinnites cortesii*, I have also observed in the living species *H. gigantea*, Gray, and *H. sinuosus*, Gmelin.

Ostrea we have shown becomes attached at the close of the prodissoconch period, and the same is true of Plicatula (see section XI); as soon as attached both these genera, as in Hinnites and Mulleria, assume the irregular ostrean form of shell, losing entirely the symmetry in the valves of the early unattached period.

Pernostrea, a Jurassic genus, is of interest in these studies. According to Stoliczka the shell is "rounded or oval, solid, more or less tumid, inequivalve, the left valve being in adult specimens attached; structure lamellar, resembling that of Perna . . ." Again Stoliczka says: "This genus forms a connecting link between Melina (Perna) and Ostrea, differing from the former especially by its sessile habitat, absence of a byssal sinus and strongly excavated muscular scar; from the latter by the presence of separate ligamental grooves. Externally Pernostrea is barely distinguishable from Ostrea." From our point of view, the ostrean form is due to the condition of fixation. Therefore Pernostrea is like Ostrea because it is cemented to foreign bodies. I have shown that in Hinnites, Pl. XXVI, figs. 3–4, the byssal notch disappears as soon as the shell becomes soldered to an object of fixation, as the byssal attachment at that period is abandoned and the shell assumes an irregular ostrean growth. Therefore the disappearance of a byssal notch in Pernostrea is another character fairly attributable to the condition of cemented fixation. In the species of Perna in Pl. XXVI, figs. 16–18, we find that from the typical form of this genus having a long hinge area and many cartilage pits, fig. 16, a series may be traced to a form with few cartilage pits and wing-like productions of the shell, fig. 18. If we should carry this reduction of the cartilage pits still further till only one remained while still retaining the wing-like productions of the shell we should have a form similar to the nearly allied genus Mallens. Still more to the point is the fact that in studying young Perna I have found that at first only one cartilage pit exists, which is triangular in outline and oblique in position as in Meleagrina, Mallens and Ostrea. It seems that there is no difficulty in a single cartilage pit being derived from many cartilage pits; so, that other points being considered, Pernostrea may very properly be considered as intermediate in form between Perna and Ostrea. As Pernostrea is known only in the Jurassic, and true oysters are known from older formations, it is best to consider Pernostrea not as in the line of ancestry of the Ostreadæ, but as a separate branch from Perna parallel to the branch on which the Ostreadæ evolved as discussed at the close of this section and in section XVI.

In looking back to the earliest known oysters, we find that they are very typical, inequivalvular ostrean forms. M. Barrande's *Pseostrea bohemica*, Barr., a form which seems referable to the oysters, is based on isolated valves attached by the umbo of apparently the left valve. His Pl. 111, fig. 2, is an upper free valve and bears at the extreme tip a rounded, very marked early stage which resembles the ostrean prodissoconch as

described and figured in this paper. Whether this comparison can be properly made can only be ascertained by a study of the specimen. Præostrea is from the formation, E. 2 and 3, Système Silurien, a period equivalent to a portion of the Upper Silurian. If a true Ostrea, it is the earliest appearance of the group yet recorded. Professor L. de Koninck figures a form from the Carboniferous as *Ostrea nobillisima*. His figures resemble a Perna, and are very much the form we might expect if that genus, or a similar one (as Perna is not known before the Trias), should have become attached. *Ostrea patercula*, Winchell, from the American Carboniferous, appears to be a true Ostrea and has the typical form of the genus.

As it is shown that the ostrean form is due to the conditions of fixation, these early and questionable species have to be looked at sceptically, as any Pelecypod adopting a fixed habitat might assume a form which in isolated specimens could well be taken for an oyster. The paucity of the Permian and Triassic formations gives but little evidence concerning the early history of the Ostreadæ, but in the Jurassic the family is well developed, and from that time on there are abundant species and individuals for study.

In the early Jurassic, Exogyra and Gryphæa are developed as well as typical Ostreas, and the question comes up as to which is to be considered the typical, least modified form of the family. I show (below) that Ostrea, the type of the family, is connected with Perna, or Perna-like forms, by important characters of anatomy and shell structure. It has been shown that the attached valve is that which is most modified in all Pelecypoda which solder one valve to a foreign body. Therefore, the same line of reasoning may be followed, and as Ostrea is near to Perna, Exogyra and Gryphæa should be considered as extremes of variation in the Ostreadæ. They are extremes of the Ostreadæ as Caprinula, Pl. XXVI, fig. 8, and Monoplenra, Pl. *id.*, fig. 9, are extremes of the Chamidæ, and in the same line of variation. The almost simultaneous appearance of the three genera of the Ostreadæ in marked abundance in the early Jurassic is probably due to the recognized law of quick development of new types of animals, together with the fact that the Trias and Permian are formations bearing few fossils, so that what Ostreadæ did exist in those periods have been but fragmentarily preserved.

After our studies in previous chapters and the present discussion of shell form we are in a position to consider the probable ancestry of the Ostreadæ. The anatomy of Ostrea bears a close similarity to that of Perna. The gills of the two genera bear a close resemblance.[1] The palps, heart, adductor muscle, position and termination of the in-

[1]Dissecting *Perna ephippium* I find that the dorsal border of each pair of gills presents the cross connecting lattice-like meshes characteristic of Ostrea. In some specimens the two pairs of gills are separate from one another throughout their extent, as represented in Pl. XXIV, fig. 10, whereas in other specimens the two median gills are connected by concrescence at their dorsal border thus uniting the two pairs of gills, as in Ostrea. The degree of concrescence varied in different specimens which possessed it; the gills being united for their whole extent or only posteriorly. That such a difference as this should exist in what is commonly considered a fundamental character is peculiar and should be studied on fresh specimens (mine being alcoholic). In a young Meleagrina, I find the two pairs of gills separate, though Woodward says they are united behind the foot. Probably he refers to the adult. In an Avicula also, I find the two pairs of gills separated throughout their extent. In both Avicula and Meleagrina the characteristic lattice-like meshes connect the lamellæ of either pair of gills on their dorsal border as in Perna and Ostrea. The anatomy of Meleagrina and Avicula as far as ascertained from my rather limited material is as near to that of Ostrea as is the anatomy of Perna, and it may be that Ostrea is a direct branch from Avicula rather than from Perna. I have adopted the latter view because the shell of Perna approaches nearer to Ostrea than does the shell of Avicula, and because in Pernostrea, an unquestionable branch from Perna, we find a form almost identical with Ostrea.

testine and mantle border are also closely alike in Perna and Ostrea. In Ostrea the foot is wanting, but probable remnants of it are preserved as the pedal muscle mentioned by Dall, *pd*, Pl. XXV, fig. 12. The prodissoconch of Ostrea is strikingly like that of Perna. In both genera it is an oval, nearly or quite equivalvular shell with umbos directed posteriorly. In both it is composed of homogeneous lime, and shows fine concentric lines of growth. The succeeding dissoconch in both Ostrea and Perna is strikingly different from the prodissoconch. In Perna it is composed of an external laminar prismatic cellular layer with internal nacreous layers. In the oyster the right valve has an external thin laminar prismatic layer, the bulk of the valve being composed of sub-nacreous tissue. The left valve, on the other hand, in the young, is composed wholly of sub-nacreous lime, not having the typical prismatic layer (*vide* p. 314). This absence or extreme reduction of the prismatic layer in the left valve of the oyster may be due to the modifying influence of fixation or to other causes, for in young Pectens a prismatic layer is found in the right valve although wanting in the left.

Having seen some important likenesses of the two genera, Perna and Ostrea, let us examine the differences and see if they can be accounted for. Ostrea is attached; this habit is acquired by many Pelecypods in widely separate groups. The loss of the foot and accompanying byssal notch in Ostrea is easily explained as the result of fixation, for such a reduction and disappearance are described in attached Hinnites, Pl. XXVI, figs. 3–4, Spondylus, Pl. XXVII, fig. 4, and Pernostrea. The shell of Ostrea is inequivalvular, of rough, irregular growth, especially marked in the lower valve, which is deeply concave; the sub-nacreous tissue is characterized by a shallow camerated structure. This form and the cameration we have shown are the result of the conditions of fixation acting on attached Pelecypod shells. Ostrea has but one cartilage pit in the middle of the line of ligamental tissue connecting the valves, whereas Perna has many pits situated on such a line of tissue, Pl. XXVI, figs. 16–18; but this character is variable in Perna and in the young only a single pit exists, figs. 30, 31, p. 329. The nepionic period, as shown in many genera in this paper, is of value in tracing relationships which are with difficulty or not at all traceable in the adult. Therefore we naturally turn to the nepionic period of Ostrea. I have not been able to trace connections between the nepionic stage of Ostrea and similar periods in Perna, but it is to be remembered that Ostrea, even at this early period, is already attached and highly modified, so that close comparisons are not to be expected. All differences seem referable to details, which are explicable on established bases of argument. We feel justified, therefore, in supposing that Ostrea is a close ally of Perna, the differences between the two genera being largely explained by the effects of the changed conditions of environment acting on the genus Ostrea. Ostrea probably descended directly from Perna or from a close common ancestor of the two genera, and by soldering its shell to a foreign body at the close of the prodissoconch period has by this means eradicated from the shell, features which might otherwise render the young referable to Perna in form.

VIII. Perna, Avicula and near allies.

Seeking on masses of *Perna ephippium*, L., preserved in alcohol, a number of young specimens were secured, which had the embryonic shell well preserved. The young were

attached by a byssus as are adults, and it was due to this fact that they were collected at the same time with the adults.

The prodissoconch of Perna, as shown in Pl. XXVII, figs. 1–3, and Pl. XXVIII, fig. 11, is very closely similar to that characteristic of Ostrea, the umbos are directed posteriorly and the histological structure is homogeneous and laminar. The succeeding dissoconch is sharply marked off from the prodissoconch by the shape of the shell and by the fact, as in Ostrea, that it is composed of lime deposited in a prismatic manner in a conchyolin matrix. These two characters are features as clearly marked and as striking in the young of Perna as they have been shown to be in the young of the oyster, fig. 27, p. 314. The byssal notch of Perna originates in the initial stages of the dissoconch, as shown in Pl. XXVII, figs. 2–3, viewed from the right side. It is a fact to note in our comparative studies that there is no indication of a byssal notch in the prodissoconch valves of Perna; and the same is true of the prodissoconchs of Spondylus, Pl. XXVII, fig. 4, Avicula, fig. 33, p. 330, and Pecten, Pl. XXVII, figs. 8–9, all tending to prove that the embryos lived a free locomotive existence as did Ostrea up to the close of the prodissoconch period and crawled, if at all, on the ventral border of the valves. As viewed from the left upper side the young shell of Perna, Pl. XXVII, fig. 1, is auriculate, but shows no indications of the byssal notch; as in the lower right valve, Pl. XXVII, figs. 2–3, the same being true of young Pectens, Pl. XXVIII, figs. 9–12. This is attributed to the fact that it is the right valve which is most affected by the presence of the byssus, for that organ in mooring the animal to its habitat passes over the edge of the right valve, as the animal lies on the right side.

The degree in which a special notch exists for the extrusion of the byssus and foot appears to bear a direct relation to the position of the axes of the body as compared with the hinge axis of the shell (relation of axes to the shell, see p. 309). In byssated Pelecypods which have the anterior portion of the body closely underlying the hinge area, a notch is always developed. As examples, may be cited Perna, Pecten, Avicula and Tridacna. On the other hand, byssated Pelecypods in which the antero-posterior axis is more nearly parallel to the hinge axis, commonly there is only a slight byssal notch, or none at all. Such we find to be the case in Mytilus, Modiola, Pinna and most Areas. In studying these genera it is evident that when the foot is close to the hinge axis a notch in the valves greatly aids in its easy protrusion; as if no notch existed the valves would have to open very widely to permit of its passage. Young Pecten, however, in virtue of the deep notch, protrudes its foot and crawls freely, while lying on the right side (see studies of Pecten), although the valves are almost closed. Genera in which the foot is far removed from the hinge line can protrude it, even if of considerable size, by a comparatively slight gaping of the valves, and a permanent byssal attachment seldom induces a considerable notch. Those in which the foot is far removed from the hinge line mostly crawl on the ventral border, with the valves raised perpendicularly, not as in Pecten and similar genera where crawling is effected by dragging the shell still lying on its right side, the foot being extended through a special notch in the right valve. From studies of Pecten I am led to believe that a notch is a feature caused by the extension of the foot quite as readily as by the existence of a byssus, although either organ would affect shell growth by its permanent existence, or activity.

The shell of Perna in the nepionic stage has not yet acquired adult characteristics.

Viewed from the left side, Pl. XXVII, fig. 1, it possesses a rounded wing anteriorly and posteriorly the wing is rounded but not produced beyond the borders of the valves. The hinge of this early period of growth, fig. 30, is markedly different from the adult. The cartilage pit is single, acutely triangular in outline, situated obliquely (as in Malleus, Pl. XXVI, fig. 19), and extends downward from the hinge area of the prodissoconch valve as in Ostrea, Pl. XXIV, fig. 19. As the shell grows, fig. 31, new cartilage pits originate on the hinge line each being triangular at first, but not as acutely so as is the first formed pit. Hinge teeth exist in young Perna (figs. 30–31), although wanting in the adult, Pl. XXVI, fig. 16. Two cardinal teeth in the right valve and one in the left are situated directly beneath the umbos. A slight posterior lateral tooth exists as well in either valve. The teeth correspond with similar teeth in a specimen of *Avicula sterna* with which they were compared and they are found in specimens of *Perna ephippium* up to a centimeter or more in height. These teeth are apparently directly inherited from Avicula, which is in all probability the immediate ancestor of Perna. During later growth new cartilage pits originate on the hinge line, and the triangular outline characteristic of the developing pits is lost, giving place to the perpendicular form of pits characteristic of the adult, Pl. XXVI, fig. 16. The hinge teeth also disappear during growth, and the form of shell characteristic of the species is rapidly built up.

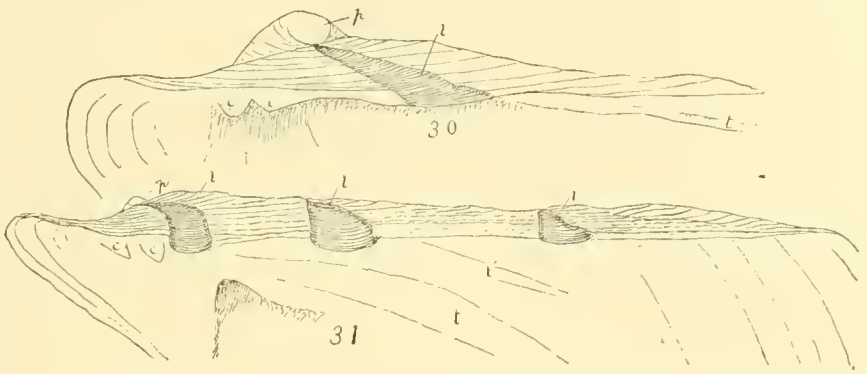


FIG. 30.—Young *Perna ephippium*, right valve; *p*, prodissoconch; *l*, single triangular cartilage pit; *c*, cardinal and *t*, lateral teeth. × 90 diam.

FIG. 31.—*Perna ephippium*, older specimen than fig. 30, showing several triangular cartilage pits and two lateral teeth. Lettering as in fig. 30. × 24 diam. (Drawn by the author.)

The anatomy of adult Perna resembles that of Ostrea as already considered, section v, and the anatomy of the prodissoconch period of Perna is probably closely like that described in the oyster, p. 300, Pl. XXIV, figs. 1–2. At least one difference, however, exists, and that is the presence of a well-developed foot. The foot of Perna as indicated by the position of the notch in the succeeding dissoconch growth (Pl. XXVII, figs. 2–3) occupies an antero-ventral position in the prodissoconch shell, and a similar position was occupied by the foot in the young prodissoconch period of Avicula, fig. 33, p. 330, Pecten, Pl. XXVII, figs. 8–9, and Anomia, Pl. XXIX, figs. 6–7. The position of the foot may be considered as affording evidence concerning the anatomy of the prodissoconch stage, as it doubtless closely underlies the anterior adductor muscle, its normal position in dimyarian Pelecypods, for Perna was unquestionably dimyarian at that stage. The foot of adult Perna is small compared with that found in Pelecypods where it is used actively in locomotion; it bears a deep longitudinal distal cleft as in Pecten, and from a second deeper proximal cleft, the byssus originates. The prodissoconch of Perna in shell features and implied anatomical parts is referable in origin to the Nuculoid radical, which

is also represented by the prodissoconch in Ostrea, Avicula, Pecten, etc. (see full discussion, section XV).

In studying fossil Pelecypods we find many species of Palæozoic Avicnloids which are directly comparable to the nepionic stage of Perna, Pl. XXVII, fig. 1. Some species of Leioptera and Leptodesma, as figured by Hall in the Palæontology of New York, Vol. v, part I, are very similar to young Perna. The most striking resemblance, however, is found in species of Rhombopteria (gen. nov. described in section XVI) from the Silurian, as figured by Barrande. *Rhombopteria glabra*, sp. Münst. (see Barrande, Pl. 228), is almost identical in form with young Perna. The form of shell found in the adult of species of Rhombopteria is shadowed in the stages of development of many genera of the Aviculidæ and their allies as Avicula, fig. 32, p. 330; Pecten, Pl. XXVIII, fig. 9, etc. From these close comparisons, Rhombopteria is selected as the radical from which these genera are evolved as discussed in section XVI, and represented graphically in the table at the end of that section. The prodissoconch of Perna in common with that of Ostrea, Avicula, Pecten, etc., is the representative in the ontogeny of the individual of

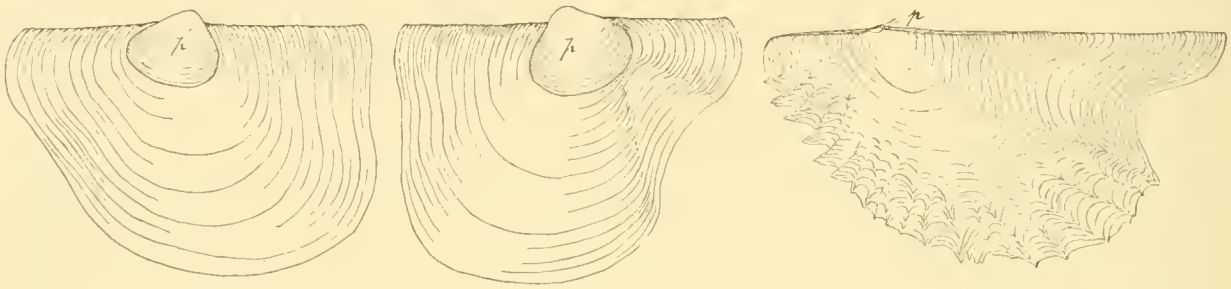


FIG. 32. FIG. 33. FIG. 34.

FIG. 32.—Young *Avicula sterna*, showing, *p*, the prodissoconch and succeeding nepionic stage, viewed from the left side.

FIG. 33.—Same specimen viewed from the right side, showing the byssal sinus. Figs. 32–33 are drawn from the umbonal tip of a young specimen by following the lines of growth. × 38 diam.

FIG. 34.—Young *Avicula sterna*, showing a much later growth than figs. 32–34, × 6.3 diam. (Drawn by the author.)

the Nuculoid radical from which the whole group evolved (section XVI), and the succeeding nepionic stages are referable in origin to species of Rhombopteria the next step up in the phylogeny of the group. The prodissoconch, also the teeth, single triangular cartilage pit and form of the shell in the nepionic stage of Perna show how closely stages in growth may be compared to ancestral kindred and how valuable such stages are in tracing the phylogenetic history of groups.

The developing shell of Avicula presents characters of interest in themselves and of great value in our phylogenetic studies. Through the kindness of Prof. A. E. Verrill,[1] I recently received some specimens of young *Avicula sterna*, Gould, from Panama. The specimens were growing thickly on the branches of Gorgonias, to which they were attached by a byssal fixation. A well defined prodissoconch exists at the umbos of the valves, figs. 32–33, and the right valve of the prodissoconch is somewhat larger than the left valve. The umbos of the prodissoconch are directed posteriorly; it is composed of homogeneous lime and shows fine concentric lines of growth. The prodissoconch of

[1] I am indebted to Professor Verrill of Yale University, for other specimens besides the Aviculas mentioned, and I am also indebted to Dr. C. E. Beecher of the same institution for many valuable specimens of developing Pelecypods; some of which are described in this paper.

Avicula is closely comparable to the same stage of Ostrea and Perna as described, and the anatomical features of this stage of Avicula are doubtless similar to those of the genera mentioned.

The early dissoconch growth of Avicula is sharply defined from the prodissoconch by its changed form and histological structure. Whereas the prodissoconch is composed of homogeneous lime, the dissoconch externally is composed of prismatic cellular tissue, with an inner layer of nacreous tissue (compare with Ostrea, fig. 27, p. 314). The delicate spinose productions of the epidermis are made up of prismatic tissue like the rest of the superficial layer of the shell. In form the nepionic stage of the dissoconch is subrhomboidal, fig. 32; the hinge line is produced beyond the borders of the prodissoconch in a straight line and anteriorly is terminated by a slightly auriculated wing; posteriorly the wing is slightly rounded at the hinge line, and is not produced beyond the free borders of the valves as in later stages. In the right valve, fig. 33, the byssal sinus originates with the introduction of the nepionic stage and is progressively produced to the free border of the valves. At this stage, the developing shell of Avicula is closely like the developing shell of Pecten at the same stage, Pl. XXVIII, figs. 9–10 and Perna, Pl. XXVII, fig. 1. It also approaches near to the form of the young of many living and fossil allied genera, and in its left valve, fig. 32, bears a close resemblance to the adult of Rhombopteria, the primitive radical of the Aviculidæ (see section XVI). During the later growth of *Avicula sterna*, fig. 34, the posterior wing is gradually produced in an increasingly sharper posterior extension as indicated by the lines of growth in the figure, and soon the full characters of the adult are introduced. The stage represented in fig. 34, is compared in section XVI, with the ancient genus Leptodesma, which this stage probably represents in the ontogeny of Avicula. In the youngest specimen of Avicula observed, the hinge teeth are similar to those of the adult, and the cartilage pit is triangular, oblique and produced downwards from the hinge line of the prodissoconch as in Perna, fig. 30, p. 329. Similar characters to those found in *Avicula sterna* are shown in a specimen of *Avicula atlantica*, sp.? sent me by Dr. C. E. Beecher.

The prodissoconch of Avicula as in Perna and Ostrea, represents in development the Nuculoid radical of the whole group (discussion, section XV). The nepionic stage which is the next stage in the ontogeny of the individual corresponds closely with, and is the representative of Rhombopteria, which is the second step upward in the phylogeny of the group (see table, section XVI). The third stage in Avicula in which we find the posterior wing produced and the anterior wing auriculate, fig. 34, bears a close resemblance to typical species of the genus Leptodesma which is considered as the third step in the phylogeny of the group (serial steps and discussion, see section XVI). Thus Avicula in its development represents very fully the phylogeny of the genus, as also seen in Perna and very clearly in Pecten, section X.

A specimen of young *Meleagrina glabra*, Gould, from New Zealand, No. 584, Yale University Museum Collection, has a prodissoconch and succeeding nepionic dissoconch similar to that of *Avicula sterna*. One difference, however, exists, in that the young Meleagrina like the adult has no cardinal or lateral teeth as in Avicula.

Specimens of *Monotis tenuicostata*, from the Jurassic of the Black Hills of Dakota, were loaned me by Dr. Beecher for study. The prodissoconch is preserved in both valves. It has the umbos directed posteriorly, and resembles the prodissoconch of Avic-

ula as far as can be ascertained in its partially eroded condition. The byssal sinus of the right valve originates in the initial stage of the dissoconch growth, as in Avicula.

In *Pseudomonotis echinata*, sp., Sow., I have been able to observe the condition of the young in specimens from the Cornbrash of Wilts, England, No. 10737, Museum of Comparative Zoölogy. A well-preserved prodissoconch like that of Avicula, exists at the umbo of either valve. The nepionic stage of the left valve, which seems to be the more normal, least modified valve in this species, is sub-rhomboidal in form and resembles the same stage of Avicula, fig. 32, p. 330. In the right, flattish valve, the byssal sinus originates with the introduction of the nepionic stage as in Avicula, etc.

In some well-preserved specimens of right valves of *Oxytoma inequivalvis*, sp. Sow., from the middle Lias, Pl. XXVII, fig. 7, I found a well-preserved prodissoconch. As in related genera the umbos of the prodissoconch are directed posteriorly, and the byssal sinus originates with the introduction of the nepionic stage on the ventral border of the prodissoconch as shown in the figure.

In specimens of Cassianella from the Triassic, a prodissoconch has been found similar to that of Avicula. It is worth noting that Cassianella is from the oldest geological formation from which I have so far succeeded in finding a Pelecypod with the prodissoconch still intact. Dr. Beecher sent me recently specimens of *Cassianella decussata*, Münst, which show the feature mentioned, fig. 35. The prodissoconch is ovate with umbos directed posteriorly, and it is sharply defined from the succeeding dissoconch, as in Avicula and allied genera. The nepionic stage of Cassianella is similar to the same stage of Avicula (compare tip of valve of fig. 35, with the whole valve of fig. 32, p. 330). The prodissoconch has also been observed in *Cassianella grypheata*, Münst, from the Triassic.

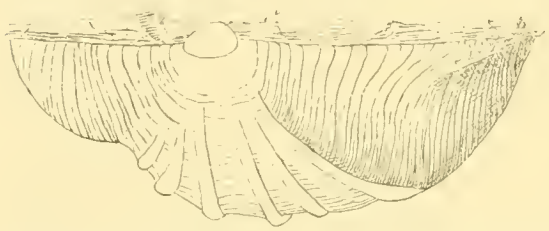


FIG. 35.—*Cassianella decussata*, tip of left valve, showing, *p*, prodissoconch, and early dissoconch growth. Original in Yale University Museum. × 30 diam. (Drawn by the author.)

In specimens of *Vulsella rugosa*, Lam., kindly given me by Professor Verrill, I have found stages of interest. At the umbos of a young individual, fig. 36, a well-defined prodissoconch exists similar to that of Avicula. The prodissoconch is oval with umbos directed posteriorly. It is composed of homogeneous lime, and bears fine concentric lines of growth. The nepionic stage of the dissoconch, as in related genera, is sharply defined from the prodissoconch by its changed form and histological structure. The shell of the nepionic and later stages is composed on the outside of prismatic cellular tissue, with nacreous tissue in the deeper seated parts. The form of the nepionic stage is sub-rhomboidal, bearing a certain resemblance to the same stage of Avicula, fig. 32, p. 330; but the wings are almost lost sight of in Vulsella. During later growth the hinge line becomes twisted out of the straight line and commonly, for a brief extent at least, curves around the ligamental area as shown in fig. 36.

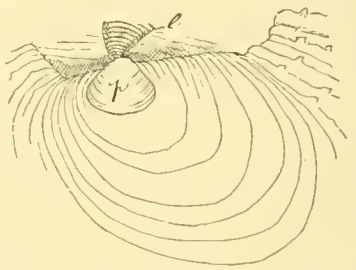


FIG. 36.—Tip of valve of young *Vulsella rugosa*, showing, *l*, cartilage pit; *p*, prodissoconch, succeeded by the early nepionic growth. × 38 diam. (Drawn by the author.)

The genera Malleus and Pinna might be considered in this section, but I have not

succeeded in getting very young specimens of either genus. The observations which have been made on the development of these genera are given in section XVI.

IX. Pecten. Anatomy and Habits.

Material collected at Buzzards Bay, in 1888 afforded an opportunity to study *Pecten irradians*, Lam., fig. 37, which is common on the southern shores of Cape Cod. Through the kindness of Dr. Dall, I have also been able to study the young of several other species from the collections of the Smithsonian Institution at Washington. The consideration of the anatomy and life habits of *Pecten irradians* is taken up in this section and a study of the shell of that and the other species studied is described in section X.

On the fourth of August, in examining the glass plates in my drain-pipe traps (described in section II), a number of extremely young Pectens were found. These specimens proved of great interest on account of the shell form and structure and also on account of anatomical features and the habits which I had the opportunity of observing, as they were kept alive for several days. No very young specimens were found on the sand-bar immediately around the drain pipes although diligently searched for, and the traps were a most invaluable assistance in catching extremely young molluscs which were easily seen on plates of glass by allowing the light to strike them obliquely.

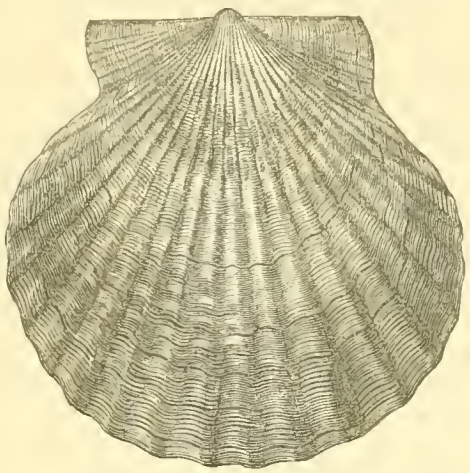


Fig. 37.—Adult *Pecten irradians*, Lam. Life size. (From Binney's Gould.)

The specimens found on the fourth of August varied slightly in size as shown in Pl. XXVIII, figs. 9–12. A few of the same age were found on the glass the next day; but later none of these youngest stages were seen. The habits of these were alike in all the individuals observed and the anatomical features were the same as far as traced.

The young Pectens, Pl. XXVIII, figs. 1, 9, 12, were free, crawling on the glass. No byssus was observed until a considerably later stage and it is safe to say that this early period has not yet developed the habit of byssal fixation. It is a free period, preceding the byssal period. The young scallops were extremely active crawlers with a highly developed foot, which is capable of extreme prolongation, Pl. XXVIII, fig. 1, and is often produced beyond the edges of the valves to a length equal to the whole height of the shell. While lying on the right valve, the foot is extended through the notch close under the hinge line and is attached by a sucker-like action to the glass, shortening its length. It thus drags the shell along on its right side. The motion is very rapid and the little creature quickly passes over a considerable distance. Shells were frequently observed to clap as in the adult; but they did not swim by this means and it is quite possible that they were not capable of doing so, as special features of the mantle which serve the adult in swimming were not yet developed. The foot is so mobile and extensible that it may be twisted and turned in any direction at the will of the animal.

Older scallops and the adults lie on the right valve, and are rarely found lying on

the left side. This latter position, is due probably to an accidental overturning, which the scallop alters at an early opportunity. Professor Hyatt informs me in a letter that he has examined over three hundred specimens of *Pecten irradians*, all of which lie habitually on the right valve. The upper, left valve very commonly is more or less overgrown with algæ, but I have never observed them on the lower right valve. This habit of lying on the right valve is characteristic of many related genera as Perna, Spondylus, Plicatula, Hinnites, and Anomia. Patten (53) in his studies of *Pecten Jacobæus*, says that this species which has a deeply concave right valve and a flat left valve, lies habitually on the right side, and if turned on the left side in an aquarium, soon rights itself. The studies of young *Pecten irradians* were interesting on this point. I turned them several times on the left valve intentionally and in every case they almost immediately extended the foot with which they laid hold of the glass, and with a sudden jerk righted themselves, showing that they were uneasy in the reversed position. While actively crawling, the heart action is very rapid as may be seen through the translucent valves.

The foot of Pecten is marked by a deep groove in its distal portion and by means of this groove is capable of laying hold of objects of support by a distinctly sucker-like action. By this means they are capable of suspending themselves and I have inverted a glass slide on which a young Pecten was crawling and seen it hang perpendicularly suspended by the foot. This only applies to the very young, as older individuals have not the power in sufficient degree to support their weight. The crawling action may, however, be seen in older specimens more easily than in the very young, as they are large enough to be observed without the aid of the microscope.

The foot of a young Pecten has a well developed posterior retractor muscle, *pr*, Pl. XXVIII, fig. 1, on the left side. It takes origin in the proximal portion of the foot and is attached to the left valve on the dorsal border of the adductor muscle. A dissection of a Pecten of the same age as that of Pl. XXVIII, fig. 2, showed the posterior retractor inserted behind the adductor in its normal position. An anterior retractor was also observed attached to the shell in the umbonal region. It is an interesting fact that in *P. irradians* there is only one posterior retractor of the foot, and that one, the left retractor, whereas normally there are two posterior retractors in Pelecypods, one of which is inserted in either valve on the dorsal border of the posterior adductor muscle. This important peculiarity of the absence of a right retractor is apparently due to the fact that Pecten habitually lies on the right valve. When lying in this position it is obvious that the left retractor is in the direct line of traction, while crawling with the foot extended at an angle so as to reach the ground; whereas the right retractor, if it exists, would not be in the line of traction and has disappeared probably from relative disuse and atrophy.[1] In adult *Pecten magellanicus* both posterior retractor muscles are wanting, and it is stated as characteristic of the genus that the posterior retractors are absent or present only on the left side. Another feature due to this changed position in the mechanism of parts is the relative situation of the cleft in the foot. In Pelecypods which have a cleft in the foot and also crawl on the ventral border of the valves, the cleft is in the ventral border of

[1] A similar disappearance of the right retractor muscle exists in Anomia, Pl. XXIX, figs. 1–2. Lacaze-Duthiers has demonstrated it in adult *Anomia ephippium* and he there ascribes the loss of the right retractors to disuse and atrophy brought about by the peculiar position of the muscles and their relations to the byssal plug.

the foot as seen in Mytilus, Modiola and Nucula. On the other hand, in Pecten, Pl. XXVIII, fig. 1, Anomia, Pl. XXIX, fig. 2, and their allies which lie on the right valve, the cleft in the foot is in the right side, this being the side apposed to the ground in crawling. Whether the position of the cleft has changed, or the apparently changed position of the cleft is brought about by a twist in the foot, is not known.

Young *Pecten irradians* differs from the adult in many features of anatomy and habit. I will first consider the condition in the young and will call attention to the differences when discussing older stages. The mantle border of the young, Pl. XXVIII, fig. 1, is a simple thickening of the edge as shown more highly magnified in Pl. XXVIII, fig. 6. It has not yet acquired the complex structure of the mantle border of the adult. The eyes are arranged on the border, one in each plicated fold of the shell. As the plications in the two valves alternate, so the eyes alternate on the two mantle borders, each retaining a position in the furrow of its apposed valve. The tentacles at this stage alternate with the eyes, as shown in the figures; they are highly extensible, sensitive, prehensile, and are covered with papillose projections. When crawling, the young scallops use the tentacles actively and they constantly lay hold of the glass by their sensitive tips. Whether they assist in crawling by their prehensile activity is not known; but it is possible. They will wind the tips around a body put in their way, such as a needle or pencil point, and I have seen very young Pectens suspended from the glass sides of a beaker by the clinging power of extended tentacles, the animal being otherwise completely inactive.

At a little later date, a few Pectens were found considerably older than those thus far considered. The eyes of this stage, Pl. XXVIII, fig. 2, are still single in each plication of the shell, no more having yet appeared; the active tentacles, however, differ from the earlier stage, fig. 1, in that there are now two alternating with each eye. The mantle border has as yet no perpendicular wall or guard tentacles (described later) but presents one striking feature. When at rest the two borders are protruded beyond the edge of the shell in a short tubular form at the base of the dorsal[1] ear as shown in Pl. XXVIII, fig. 2. At this point excurrent action takes the direction indicated by the arrow and a rapid but intermittent outflow may be traced by means of the contained particles of effete matter. This extension of the mantle is at that time a pseudo-siphon; it is composed of delicate tissue and is retracted and extended exactly as may be observed in the anal siphon of young clams (*vide* section XIV), but it differs from a true siphon in that the walls are not joined by the concrescence of their apposed borders. No siphonal extension of the mantle was seen in Pectens younger or older than that here described, but in the adult it is important to notice that all excurrent action takes place at this same area of the shell. Dr. Dall informs me that he has seen a similar condition of siphonal extension of the mantle border in Pectens dredged from great depths.

It is an interesting fact in young Ostrea and Pecten that excurrent action takes

[1] In considering the relative position of the axes of the body to the shell it must be borne in mind that as in Ostrea (*vide* p. 309) the axes of Pecten are different from those of typical dimyarians (Pl. XXV, fig. 8). The position of the palps and foot in Pecten indicates the umbos as the anterior end of the shell, the free ends of the valves are posterior, and the gills lie on the ventral border. The ear possessing the byssal notch through which the foot extends is therefore the ventral ear, not the anterior ear as commonly considered; and the ear on the opposite side is correlatively the dorsal not the posterior ear.

place at one definite area. These genera have mantle borders separate around the entire margin of the shell; yet the outflow is not in any direction as might be supposed, but is limited to one direction.

The gills of Pecten of the age of Pl. XXVIII, fig. 2, consist of four sets of filaments all equally developed, but there is none of the irregularity of development of the separate gill lamellæ described in the oyster. The inner pair of gill filaments are reflected inwards and the outer pair are reflected outwards as in the adult, Pl. XXIV, fig. 12. The reflected borders are about half the total length of the direct borders whereas in the adult the reflected borders are proportionately longer. This condition in the young was doubtless preceded by a condition in which the filaments were simple, straight processes without reflected borders as described in young Ostrea and Anomia. The gills are ciliated but have not yet the ciliated interfilamental knobs or processes existing in the adult. There are no septa joining the direct and reflected portion of the filaments, characteristic of the adult, observed at this early stage.

When a Pecten of the age of Pl. XXVIII, fig. 2, had been kept in confinement for a few days it became attached by a byssus and from my observations it is probable that, up to this period, the young lead a free, crawling existence without any fixation. With the introduction of the byssal period, as it may be called, the young Pecten undergoes a marked change in habits. Previously an active crawler, it now becomes most persistent in its byssal fixation, and leads a sedentary life. The animal lies on the right valve; the byssus is extended through the byssal notch as a number of delicate fasciated threads flattened into a disc at the point of contact with the object of fixation. The specimen if kept in a beaker of water frequently attached itself high up on the perpendicular sides of the glass to which position it had previously crawled. It occasionally broke loose voluntarily, or was intentionally detached and in a short time, commonly a few minutes, made a new attachment, showing that fixation is a feature of this condition. It was in the specimen of this early stage, when attached by a byssus, that the pseudosiphonal protrusion of the mantle was observed. When the animal is attached, the tentacles are more or less fully extended, the foot may be protruded or withdrawn, and feeding is active as indicated by fæcal discharges in the excurrent water.

Pectens considerably older than those already discussed, measuring 1–3 cm. in height, are instructive. At this age the byssal habit of fixation still exists; in fact, specimens measuring slightly over 3 cm. have been found still attached, but I have never observed such a condition in adults. Pectens 1–3 cm. high, though retaining the byssal habit, are not as constantly attached and are more active, than the younger stage just considered. Two hundred or more individuals of this size were seen on the bar and perhaps half were attached. They were not observed in the act of crawling but they are capable of swimming actively as later described. On account of the size of the specimens it was easy to observe the process of formation of the byssal fixation. In observing it, the scallops should be confined in a dish as every movement is then clearly perceptible. Lying on the right valve, the foot is extended on the surface of the dish, the flattened distal portion taking a firm hold as if about to crawl. This position is maintained for a moment or two and then the foot is withdrawn within the body, by the motion of retrac-

tion it draws out, or spins, the byssal thread, which the creature had fixed to the surface of the dish while the foot was laid closely against it. Soon the foot is again extended, pressed flatly against the dish and another byssal thread is spun. The second byssal thread is always attached at a point a little removed from the point of fixation of the first thread; sometimes the two are separated by a distance of two or more millimeters. Additional threads may be spun; but three was a common number with specimens in confinement. Those on the bar, especially the larger individuals, frequently spun a large number of threads in the byssus. The byssal gland is situated in a proximal cleft-like depression in the foot separate from the more distal cleft-like depression which serves the animal in crawling, so that between the two there is a slight interspace without a cleft. Frequently when forming the byssus, the foot may be arched up in this interspace, Pl. XXVIII, fig. 7; the hold being maintained by the tip of the foot and at the same time the byssal cleft being pressed closely against the glass, so as to make the fixation of the byssal thread. While spinning the byssus the scallop is preoccupied and pays little attention to pricks or stimuli which at other times would meet with immediate response.

The attached scallop commonly remains fixed for a considerable time. If disturbed, however, or at will without apparent cause, it may break the byssal attachment by clapping its valves. It then commonly swims about, soon renewing, or not, the attachment as the impulse moves it. If one break the byssus loose it is torn out from the foot and left clinging to the sides of the dish. On examining separated threads we find that the proximal portions of the several threads are generally coalesced into one band, the distal portions being separately attached to the glass by expanded disc-like extremity. The threads may measure a centimeter or more in length but are more often shorter. In attempting to preserve specimens of Pecten in alcohol with the byssus intact it was found that they immediately detached themselves. Success was attained however, by first paralyzing them with cocaine, adding the solution gradually to a small volume of sea water.

The mantle of Pectens 2–3 cm. high has acquired adult characters. In young stages, as shown, the eyes are situated one in each plication of the shell and a single tentacle alternates with each eye, Pl. XXVIII, figs. 1 and 6. Later the position of the eyes being the same, two tentacles alternate with each eye, Pl. XXVIII, fig. 2. In the age under consideration, as in adults, the eyes are for the most part situated in the plications of the shell, but in addition to one eye in each plication, new eyes have arisen between those first formed. The new eyes, however, do not appear at regular intervals as did the first-formed eyes. In each mantle border may be counted (as noted by Verrill) about forty eyes, and between them are a large number of tentacles instead of only two as in the earlier stage. These marginal tentacles, like those in the young, Pl. XXVIII, figs. 1 and 6, are papillose, extensible and active, frequently winding about a small object in a prehensile manner.

Besides an increase in the number of eyes and tentacles, the mantle border of Pectens, of the age under consideration, has developed new features not seen in earlier stages. The border is produced perpendicularly in a thick marginal wall or curtain which has important functions. This wall is highly developed along the plicated borders of the valves but is reduced in thickness, and height as the base of the angle forming the ears,

fig. 37, p. 333, is reached. It is richly pigmented on its outer face and marked by perpendicular folds and ridges. Just below the free, inner margin of the mantle wall it is thickly set, with small equidistantly placed, arcuate tentacles, diagrammatically shown in Pl. XXVIII, fig. 4, which may be called guard tentacles from their functional use. These tentacles are yellowish, not papillose, incapable of extension and move only in one plane. When the scallop is at rest the guard tentacles stand upright. In young individuals the tips of the tentacles of either mantle wall come in apposition, so that a grating or guard is formed between the separated mantle walls. In virtue of this grating no large body can pass into the gill chamber, while the animal is feeding with valves open, without striking the guard tentacles. Collision with these tentacles commonly causes the animal to shut its valves quickly. I say commonly, for irritation sometimes fails to produce the expected result. When swimming, the guard tentacles are turned outward and laid flatly against the outer border of the mantle wall. In adults the valves frequently are so widely separated that the tips of the guard tentacles are not in apposition, and the tentacles are less sensitive to stimuli than they are in young scallops of two or three centimeters in height. The guard tentacles are arranged equidistantly on the borders of the mantle walls from the base of the ventral to the base of the dorsal ear. The remaining portions of the mantle walls which are relatively slight and low, bear no guard tentacles. It is to be noticed, that the regions free from guard tentacles are the regions marked by the extension of the foot when young on one side and on the other marked by the excurrent flow of effete water, as well as by the flow of water when swimming.

The mantle borders of young and adults are separated for the greater part of their extent, being confluent on the hinge line and for a slight distance toward the byssal notch, on the ventral border. Dorsally they are confluent to the point marked as the inner angle of the ear, fig. 37, p. 333, being a somewhat greater distance than that of the ventral confluence. This relative confluence is correlated with the functional needs of the animal, as excurrent action takes place dorsally over such an area that it is not affected by the partial union of the mantle borders, whereas ventrally the foot actively swings up to the hinge line, requiring and maintaining a greater separation of the borders to that point. The mantle border is very broad and strong, and numerous, well-developed, radial muscles which bifurcate and anastomose freely serve to retract it. The muscles are more highly developed in Pecten than in any other Pelecypod studied, which fact is probably correlated with the active swimming habit.

It is stated that Pecten swims by clapping the valves, but how the motion is effected and the direction in which the animal moves has not been studied so far as I am aware and seems to be commonly misunderstood. The swimming habit of Pecten is one of the most striking features of this genus, and it is accomplished with such energy and rapidity that the creature attains great speed. In swimming, as when at rest, the left valve is always uppermost, and the plane of the edges of the valves is inclined to the surface of the water at an angle of about 45°.[1]

It is best to study the swimming in young Pectens some 3 cm. high, as at that age it is more easily seen than in adults, and does not differ from what may be observed in

[1] The Pectens in which the swimming habit was studied were confined in small aquaria, and it is possible that the angle given and some other details might vary slightly if swimming freely in the open water.

them. Lying on the bottom with tentacles extended, the scallop suddenly folds the guard tentacles back so that they lie closely against the outer border of the perpendicular mantle wall. The valves are then closed by a quick action of the adductor muscle and water is forcibly expelled. The first water expelled is driven out posteriorly in the direction of the arrow *a*, Pl. XXVIII, fig. 8, and if this were the only or the main direction in which a current is expelled, the animal would by impact of water be impelled in the opposite direction or anteriorly; but the act of swimming is more complicated than this would indicate. When the valves have closed to a slight extent the borders of the two thick, perpendicular mantle walls come in contact and then no more water passes out as indicated by the arrow *a*, but instead, during further closure of the valves, it is forcibly ejected from the lower border of one ear, where the mantle wall is low and thin, as indicated by the arrow *b*, Pl. XXVIII, fig. 8. The water expelled at the point *b* is the most forcible current and probably of the greatest volume; by its means the creature is impelled in the direction of the arrow, *c*. The valves open quickly and clap again. The second time as before the first water is driven out posteriorly; but when the mantle walls come in contact, the direction of the excurrent water is again changed and is forced out from the lower border of one ear in the direction of the arrow *d*, Pl. XXVIII, fig. 8 *a;* being the strongest current, it impels the animal in the direction of the arrow *e*. This striking difference is noticeable, viz.: that at successive claps the water is driven out from alternate ears, first on one side and then on the other. The resultant action of the several currents and successive claps, illustrated in Pl. XXVIII, figs. 8–8 *a*, is therefore to drive the animal in the direction of the free borders of the valves or posteriorly. It is due to the alternate expulsion of the water first from one ear and then from the other as described, that the animal presents a succession of zigzag jerks in swimming. The direction of the current alternately to the two ears appears to be voluntary, as a scallop can scuttle over the bottom of a dish in a sidelong direction by successively expelling the water at each clap from one and the same ear. The action of the first current of water expelled posteriorly, before the mantle walls come in contact, gives the animal an upward jerk and it is in virtue of this jerk combined with the momentum in a posterior direction that it maintains its position on the surface of the water and also the high angle to the surface which it presents in swimming. The current driven out posteriorly in the initial closure of the valves is so powerful that water may be squirted by adults to the height of five inches or more from the surface by this action.

In studying the shell we find a feature correlated with the swimming habit in the incomplete closure of the valves on the eared areas; so that when the free borders of the valves are in immediate contact there is still sufficient space for excurrent action at these areas, and the valves close completely at each clap, for there is in swimming a sharp clicking noise which could be caused only by the striking together of the valves. Scallops are said to migrate in bands, being seen swimming in large numbers at some seasons of the year. They are among the most active of all Pelecypods and a careful study of their habits would doubtless prove fruitful and highly interesting.

As stated, in young scallops, the outflowing water which has served the function of aeration is passed out from the shell at a definite point on the dorsal border as indicated by the arrow in Pl. XXVIII, fig. 2. This is equally marked in character and more notice-

able in the adult. In such the water is driven out so forcibly by the rapid ciliated action of the gills that a rapid gyrating current was imparted to the whole mass of water in a large dish or preserve jar in which the animal was. Further, several times on turning a scallop over, so that the excurrent action took place in the opposite direction, almost instantly the whole mass of water responded and moved in the reversed course impelled by the changed direction of the current. The fæces of Pecten may be seen escaping in pellets, the form of which in section is that of a clover-leaf, and they are produced in more or less drawn-out ropy masses, Pl. XXVIII, fig. 5; in one instance observed, measuring 14 cm. in length. Ryder (60) observed that the fæces of the oyster have a distinct almost horse-shoe form, due to the shape of the intestinal tract and in insects the form of the fæces is often a specific characteristic. It is possible that a study of this feature in molluscs might show similar results.

The adult of *Pecten irradians* is a free swimmer. No indications of a byssal fixation were seen at this age, and the foot is a highly atrophied organ. I have never seen the foot extended beyond the margin of the valves in the adult, although it is so active in the young, and it may then fairly be considered a retrograde and probably functionless organ. There is, therefore, a series of periods of habits in the life of Pecten. In the prodissoconch stage of Pecten (discussion later, section X), it is either a veliger swimmer, or crawls on the ventral border of the valves; in the early nepionic stage (Pl. XXVIII, figs. 1, 9, 10) it is an active crawler, lying on the right valve; in late nepionic and nealogic stages, it is attached by a byssus more or less constantly, but also has the power of using the foot; in the adult, it is a free swimmer and the habits of crawling and byssal fixation seen in the young are lost. Some species, as *Chlamys* (Pecten) *varius*, are said to retain the byssal habit of fixation throughout life.

Frequently Pectens show an extensive loss or injury of the mantle. One adult specimen observed had the left lobe on the ventral side entirely wanting, and the corresponding lobe on the right side was destitute of the eyes, tentacles and pigment. The damaged lobe was bereft of sensation, the creature showing no response when it was pinched or shadowed; but the animal was apparently uninjured otherwise. Such injury is probably due to the attacks of predatory animals, as when lying with its valves wide open it is an easy prey. Some indications pointed toward disease, and the loss of the mantle may be due to that cause. That scallops suffer a severe loss or injury to the mantle and recover, is amply proven by frequent specimens of mended shells. The margin of the shell is not injured by the predatory attacks (if such they are), but further shell growth is prevented at the injured point by the loss of the mantle. When one mantle border is injured, the other repairs the damage which would be caused by local want of shell growth, by curving the shell deposition of the uninjured side rapidly inwards, thus obviating the deficiency of the injured area. This ingrowth is probably induced by the lack of resisting support on the part of the damaged border. Adults which have been thus damaged in youth show that in time the injured mantle border is renewed, and normal shell deposition takes place, the early damaged period being indicated by hollow-like, uneven depressions in the shell surface. In the oyster I have never seen injuries to the mantle in living animals, and no evidence of serious injuries, later repaired, are noticeable in a study of shell growth. The oyster is more sensitive to touch than the

scallop, the valves are less widely separable, when open, and at time of danger stay shut, instead of opening almost immediately after closure, as with scallop shells; therefore, the oyster is less liable to attack, at least from certain classes of enemies, than is the scallop.

A surprising want of sensibility is noticeable in adult Pectens. It is often possible to insert a quite large body into the shell before it closes; but the young are more sensitive. Frequently pricking the mantle border with a needle produces little effect in adults. Both adults and young are sensitive to light, so that passing the hand or even a pencil in *front* of the valves they will quickly close, as described in *Pecten jacobæus* by Patten. They open almost immediately, however, and frequently repeated stimuli soon lose their effect.

Pecten irradians is hermaphroditic, the reproductive organ is of large size, and the two sexual functions are distributed regionally. The gland as a whole is roundly triangular, extending between the gills on the ventral border of the adductor muscle, while anteriorly it passes into and is lost in the liver mass. The gland is composed of two distinctly marked portions or areas. The ventral area is pinkish white and consists wholly of the male or sperm-bearing portion; the dorsal area is brownish-yellow in color and consists of the female or egg-bearing portion of the gland. The divisions of the organ lie parallel, but anteriorly the whole mass is male, while the female portion occupies the larger part of the posterior portion of the organ. The whole gland is more or less pigmented with black, especially on its ventral keel. Abundant active spermatozoa were found in the pinkish or male portion, with well developed heads and vibratile tails; but no eggs, it being solely spermatic. In the yellowish-brown dorsal portion were found developing and ripe eggs. The eggs are rounded or pear-shaped, granular, show nuclei and resemble the egg of an oyster, in size and appearance. A few spermatozoa were found in the female portion, but their presence was probably due to accidental introduction while examining the contents of the gland, as it is almost impossible to avoid introducing a few under such circumstances, and we may fairly suppose that the female portion also produces but one element. The sexual gland of *Pecten irradians*, it will be seen, is very similar to that of *P. glaber*, as described by Lacaze-Duthiers (40).

The gills of adult *Pecten irradians* are equal in length and differ much from the gills of the oyster. The filaments of the gills are reflected on themselves to such a length that the reflected portion equals about two-thirds the length of the direct portion as shown diagrammatically in Pl. XXIV, fig. 12. The reflected borders are free, not joined by concrescence with the reflected borders of opposing gill filaments, or with the mantle lobes, as in Ostrea. The filaments are joined to one another by the interlocking of tuft-like, ciliated nodes, situated at intervals. About 25–30 nodes are borne on each filament, and the nodes of contiguous filaments are in apposition. A similar structure exists in Mytilus, and is described by Peck. This connection does not exert a very strong binding influence, so that when alive the filaments of Pecten are often separated, and in alcoholic specimens are notably disconnected. The ciliated nodes serve to keep the filaments together, but quite as much to keep them separated, by an interspace to allow of the free passage of water. In the adult Pecten, at intervals of every 11–15 filaments, a delicate connecting septum or wall is developed between the direct and reflected border of the filaments, Pl. XXVIII, fig. 3. These walls strengthen the reflected borders and also

apparently direct currents of water in channels as it flows through the grate-like gill. When the reflected border of the filament ceases to cover the direct border, this wall is built into a peculiar plicated ridge or blade, *bl* (fig. cited), from the direct border of the filament, and continues in this blade-like fashion to the point of origin of the filament. The gills are suspended by fasciated membranes which connect the bases of the two pairs with the adductor muscle, with the visceral mass anteriorly, and with the mantle lobes posteriorly. Similar fasciated membranes also exist in *Anomia glabra*, Pl. XXIX, figs. 1–2.

X. Pecten. The Shell.

Characters are found in the young developing shell of *Pecten irradians* and other species which are widely different from those peculiar to the adults and a consideration of these features will now be taken up.

The first specimens of young *Pecten irradians* obtained were found in the drain-pipe traps at Buzzards Bay on the fourth of August. The youngest of these specimens is shown in Pl. XXVIII, fig. 9, viewed from the left upper side, while fig. 10 is the same individual viewed from the right side on which the animal habitually lies. Pl. XXVII, fig. 9, is a similar specimen viewed from the umbonal area of the right side, more enlarged. The prodissoconch, *p*, in the several figures is as sharply marked off from the succeeding dissoconch as in Ostrea, Perna and Avicula, Pls. XXIV, XXV and XXVII. It is separated from the dissoconch as in the genera mentioned, by its form, histological structure and inferred anatomical features. The umbos of the prodissoconch of Pecten are directed posteriorly; but they are not as pronounced and arcuate as in Ostrea and Perna. The structure of the prodissoconch is homogeneous and laminar, showing fine concentric lines of growth. There is not the slightest indication of the byssal notch in the prodissoconch valves; but it originates in the initial stages of growth of the succeeding dissoconch, Pl. XXVII, fig. 9 and Pl. XXVIII, figs. 10 and 13. As was argued when discussing Perna and Avicula (p. 329), the position of the byssal sinus in its relation to the prodissoconch shell indicates that the foot of that period of development occupied a position on the free ventral borders of the valves, its normal position in dimyarian Pelecypods. The prodissoconch stage of Pecten was doubtless dimyarian, a supposition confirmed by the shape of the shell, the position of the foot and the affinities of Pecten to Avicula and Ostrea, in which last genus two adductor muscles are shown to exist at that stage, Pl. XXIV, figs. 1–2.

The habits of the prodissoconch stage of Pecten, we know only from analogy and the structure indicated by the hard parts; but as it differs from the Ostrean prodissoconch in possessing a foot, it may be at this period, a veliger swimmer as is Ostrea or a purely crawling form. If the latter, it doubtless crawls on the ventral border of the valves as is the habit in Pelecypods in which the foot is extended from between the ventral border of the valves opposite the hinge line. Only very young Pectens show the prodissoconch still intact, as it is not retained in this genus as long as in the sedentary oysters, Avículas and Pernas. The prodissoconch of Pecten as in Ostrea, Perna, Avicula, etc., is traceable in origin to the Nuculoid radical, from which the Aviculidæ and their allies were derived (discussion, section XV, and table, section XVI).

The succeeding dissoconch growth in Pecten is clearly and sharply separated off by its changed form and histological structure. Whereas the prodissoconch shell is homogeneous and laminar in structure, the succeeding dissoconch of *Pecten irradians*, in its early stages, Pl. XXVIII, figs. 9–12, has a thin layer of prismatic cellular tissue in the right valve, the same feature having been observed in Ostrea, fig. 27, p. 314; also in Anomia, as shown in later studies. The early stages of the dissoconch growth of *Chlamys* (*Pecten*) *islandicus*, Chemn., *Pecten dislocatus*, Say, *P. magellanicus*, Gmelin and *P. monotimeris*, Con., also show marked prismatic cellular structure in the right valve. The prismatic structure of these several species does not occur in patches here and there, but extends over the whole early dissoconch shell in a thin but clearly marked layer. This is a most interesting fact as adult *Pecten irradians* does not exhibit any evidence of prismatic structure, though it is well developed in the young. Professor Carpenter in his first paper on shell structure, in 1844, says that he has seen traces of cellular structure in the Pectinidæ; but believes that it is not to be considered as constant or peculiarly characteristic of the group. In his later paper in 1848, he states that he has since found prismatic cellular structure, thin, but beautifully preserved in *Pecten nobilis*, which he figures. This is the only case I find mentioned in which prismatic structure is known in Pecten. Dr. Dall (16), however, in recent studies of deep-sea molluscs has observed prismatic cellular structure in many species of Amusium, and in the allied genera Pseudamusium and Propeamusium. In these cases the prismatic structure, though often limited in extent, was not confined to the right valve, as in my observations of young Pectens. Dall notes that this structure is especially characteristic of abyssal species of this group, in which also the shell is extremely thin and fragile. My observation of prismatic structure in the young of five species studied, proves that this feature which is not a characteristic of the group may yet be found in the young. The Aviculidæ, in which prismatic structure is highly characteristic, are in the line of ancestry of the Pectinidæ. The occurrence of prismatic structure in young Pectens is therefore a good example of the principle of acceleration of development which is that ancestral characters may be found in the young which are wanting in adult individuals.

Although prismatic structure is characteristic of the right valve in young *Pecten irradians*, the left valve in this and the other species studied has no prismatic layer. In *P. irradians*, the left valve in its early nepionic stage is marked by a peculiar pitted structure. The degree of pitting varies in different individuals, but in none was it as marked a feature as in young *P. dislocatus*, where it is highly accentuated.

In Pecten the shell of the first true dissoconch or nepionic period, Pl. XXVIII, figs. 9–10, is markedly different from succeeding stages, as well as from the early completed prodissoconch stage. The hinge is produced as a straight line and the borders of the valves descend in a curve from the extreme limits of the hinge line without possessing the ears which are characteristic of the adult in all species of the genus. The ventral border of the left valve, fig. 9, has no byssal notch but near the hinge area is produced in a lobe-like curve, the lobe projecting beyond the border of the byssal sinus of the right valve as shown in fig. 10. There are no plications of the shell at this stage although these originate early and are characteristic of the adult. The features of the ventral lobe, and the absence of ears and plications, give the shell as shown in the figures cited

a totally different aspect from that of later stages and also different from any form known in other species of the genus.

The right valve of young *Pecten irradians*, on which it rests, Pl. XXVIII, fig. 10, is marked by a deep byssal notch, originating as stated in the initial stages of the dissoconch shell as indicated by the lines of growth shown in the enlarged figure of the hinge area in Pl. XXVII, fig. 9. The border of the notch on its lower side is marked by a well defined tooth-like process, Pl. XXVIII, fig. 10. In later growth, Pl. XXVIII, fig. 13, more tooth-like processes develop and they are characteristic of young specimens up to four or five centimeters in height but none exist in the adult shell. The left upper valve overhangs the right lower valve by a slight extent along the free margins, fig. 10, as in young Ostrea and Anomia. The color of the young shell in both valves is of a light yellowish-brown.

In the consideration of Perna (p. 328) it is shown that when the foot lies close up to the hinge area in Pelecypods a special notch exists for its extrusion. The notch is required because if not existent the valves would have to open very widely to allow of the passage of the foot at a position so close to the point of union of the valves. Perhaps an equal reason for the need of the notch is the fact that such forms lie on one valve and drag the shell in crawling by extending the foot over the edge of the lower valve. They do not creep on the free borders of the valves as do ordinary dimyarians in which the foot is extended from a point far removed from the hinge line by a slight gaping of the valves, without the aid of any special sinus. As shown on p. 333, *Pecten irradians*, when very young, Pl. XXVIII, fig. 1, has no byssal fixation, the animal leading an active crawling existence. The notch may therefore be considered as a foot notch rather than a byssal notch at this period. The existence of a byssus or the constant extension of an active foot would equally affect shell growth by exerting pressure on the mantle border, thus causing its local retraction and retarding shell deposition at the point of extrusion, so that it is not necessary to imply the existence of a byssus because a notch exists at an area where the byssus would be produced if it existed.[1] This has important bearing on fossil forms which are considered as byssated or attached, if a notch exists in this region; whereas they may with equal reason be considered, as far as the notch is concerned, as free forms which crawled while lying on one side with the foot extended through a special notch produced by the existence of such a habit. This mechanical explanation of the formation of the notch in Pecten shows what close relations may be traced between the form of hard parts and the anatomy and habits of the animal.

A view of the hinge area and byssal notch of a Pecten of the same age as the above considered specimen viewed from the right side is shown in Pl. XXVII, fig. 9. The relation of the prodissoconch to the dissoconch and byssal notch is clearly indicated and it is noticeable that the left umbo protrudes beyond the right. This is due to the greater convexity of the left valve, as is also noticeable in *Chlamys islandica*, Pl. XXVII, fig. 8.

The early nepionic stages of *Pecten magellanicus*, *P. dislocatus* (traced by following

[1] In this connection a comparison may be made of the early nepionic shell of Pecten, Pl. XXVIII, fig. 10, viewed from the right side with a similar view of young Anomia, Pl. XXIX, fig. 6. The early condition of Pecten does much to elucidate the somewhat similar form of shell growth of young Anomia.

the lines of growth) *P. testæ* and *Chlamys islandica*, Pl. XXVIII, fig. 14, agree with the same stage of *P. irradians*, Pl. XXVIII, figs. 9–10, in the form of valves. This form may therefore be considered as typical of the first stage of growth of the dissoconch shell of the group. In studying genera of the palæozoic Aviculidæ, we find genera that agree closely in appearance with the young shell of Pecten; especially when it is viewed from the left side as in Pl. XXVIII, fig. 9. The genera Actinoptera, Leiopteria and Leptodosma, as figured in Hall's Palæontology of New York, are very comparable to this early stage of Pecten. A still nearer comparison may be made in species of the Silurian genus Rhombopteria (gen. nov.) fig. 51, section XVI, which are closely comparable to young Pecten in all the species observed. Rhombopteria is selected as the primitive radical of the Aviculidæ and their allies (see discussion and table, section XVI), and it is one of the best proofs of the correctness of that view that the nepionic stage of Pecten so closely corresponds with that early type. In the studies of Avicula and Perna, the young of those genera, fig. 32, p. 330, and Pl. XXVII, fig. 1, is compared closely to the same ancient genera to which I have just compared young Pecten. A comparison of young Pecten, Pl. XXVIII, fig. 9, with the similar period of growth of young Avicula and Perna, in the figures cited, shows that at this early age the three genera are closely similar. Differences in the angles of contour exist, especially in the hinge line; but they are slight in degree, and the important phylogenetic conclusion may be made that these genera in the nepionic stage are so alike that they are referable in their inherited form to the same ancestral types. Thus we see that the form as well as the prismatic structure of the shell of young developing Pectens may be traced to ancestral types from which the genus was evolved.

A stage of shell growth in *Pecten irradians*, Pl. XXVIII, figs. 12–13, later than that just considered, shows the beginning of features characteristic of the family and species to which the young scallop belongs. Plications similar to those of the adult begin to be marked in either valve and ears to be developed, as shown in fig. 12, viewed from the left side, and fig. 13, viewed from the right side. The byssal notch is strongly marked, as in the earlier stage, and it is to be observed that the notch is much deeper relatively in this early, active, creeping stage than in the adult, where the use of the foot as a creeping organ is lost. The base of the byssal notch, fig. 13, shows four marked, tooth-like processes, of which one only was present in Pl. XXVIII, fig. 10. These teeth may prove of value in tracing relationships; but their function, if any exist, is not understood. The plications of the shell are clearly defined and originate suddenly, indicating a stage by their introduction. The plications are like those of the adult, fig. 37, p. 333, and they are the same which are retained throughout life, no new plications, originating by bifurcation or interposition, in this species. The left upper valve does not extend beyond the right valve on its free margin as in the earlier stage, fig. 10.

A later period of growth in *Pecten irradians* is shown in Pl. XXVIII, fig. 2. The ears are more accentuated than in the previous figures, though they do not bear to the whole shell the same relative size and shape, as in the adult, fig. 37, p. 333. The hinge line of this stage, fig. 2, is much shorter than in the earlier stage, Pl. XXVIII, figs. 12–13, but much longer relatively to the breadth of the valves than in the adult. In other features, excepting the depth of the byssal notch, this age does not differ essentially from the adult

in the form of the shell. Differences in the anatomy and habits, however, exist, as discussed in previous pages.

I have shown that the early, nepionic shell growth of Pecten, Pl. XXVIII, figs. 9–10, has a form referable in origin to the adults of ancient members of the Aviculidæ, and I believe that the form of the later shell growth is also of phylogenetic significance. The hinge line of *Pecten irradians*, in Pl. XXVIII, figs. 12–13, is relatively long as compared with the condition found in the adult of this or other species of Pectens, and correlatively the ears are very slightly developed as compared with the adult. The same condition of relative great length of hinge line and want of development of the ears is seen in similar stages of development of *Chlamys (Pecten) islandica*, Pl. XXVIII, fig. 14, *Pecten magellanicus* and *P. dislocatus;* therefore it may be considered as typical of developing Pectens. In Hall's Palæontology, Vol. v, Part 1, we find forms of Devonian Pectinidæ under the genus Pterinopecten which agree closely with the form of shells here figured in developing modern Pectens. The agreement is in the relatively great length of the hinge line and slight production of ears, which features characterize *Pterinopecten* and separate it from the nearly allied genus Aviculopecten. Pterinopecten is the least removed from the Aviculidæ, and is the simplest known form of the Pectinidæ. The young of Pterinopecten resembles the adult of Rhombopteria and the adult resembles the young of Aviculopecten and Pecten (see section XVI). It forms, therefore, a strong link in our phylogenetic series, and is placed as the first departure from the Aviculidæ in the Pecten line of variation (see discussion and genealogical table, section XVI).

The palæozoic genus Aviculopecten, as amended by Hall, differs from Pterinopecten in a greater production of the ears and in a relatively shorter hinge line. Turning to the developing shell of *Pecten irradians*, we find that the later growth, Pl. XXVIII, fig. 2, differs from the earlier growth, Pl. *id.*, figs. 12–13, as Aviculopecten differs from Pterinopecten. The same stage also differs from the adult fig. 37, p. 333, as Aviculopecten differs from Pecten. This later stage is therefore traceable to Aviculopecten as its ancestral representative, and also the position of Aviculopecten is clearly indicated in its relation to other genera (see discussion and table, section XVI).

The prodissoconch of Pecten as stated (p. 342) is referable in origin to the Nuculoid radical, represented in the development of the Aviculidæ and their allies as illustrated by typical genera. It is further shown that in the development of a modern Pecten we find in the first stages of dissoconch growth a form of shell, Pl. XXVIII, fig. 9, presenting characters which make it referable in ancestral origin to Rhombopteria a member of the true Aviculidæ, later succeeded by a growth, Pl. *id.*, fig. 12, bearing marked features referable in origin to an ancestral genus Pterinopecten, which is transitional between the Aviculidæ and the Pectinidæ. Still later a stage exists Pl. *id.*, fig. 2, which is referable in its inherited form to Aviculopecten, and finally, the true Pecten features characteristic of the adult, fig. 37, p. 333, are established. The geological sequence of these several groups is in the order indicated by the development of Pecten. We have, therefore, a clear case of the ontogeny of an individual illustrating the phylogeny of a group (see table, section XVI).

As further substantiation of my position that the Pectinidæ were evolved from the Aviculidæ, it may be noted that in the Challenger report, Vol. XIII, part XXV, Professor

Smith figures a deep-sea species, which he calls *Pecten aviculoides*, on account of the close resemblance which it bears to Avicula, although he considers it a Pecten. Again, a fossil from the Lias shales, as Professor Carpenter notes, was by one author named Avicula and by another Pecten, the mixture of characters being such as to sanction its being placed in either genus, according to the value attributed to different features. Carpenter affirms that it is a true Pecten because of a coarse shell structure like Pecten and an absence of prisms found in Avicula. Both these forms may properly be considered as representing in the adult a combination of types which I have shown is traceable in early stages of the developing young.

Whereas very young specimens of *Pecten irradians* are yellowish-brown, older young and adults are commonly bluish-gray, the coloration often being less or wanting in the furrows of the upper, left valve. The lower valve may be of the same color as the upper, but is generally less pigmented, especially in young individuals, and specimens are frequent in which the upper valve being dark blue-gray, the lower is nearly or quite white. This difference bears a direct relation to the amount of light to which the two valves are exposed, the paler being the lower valve, which is constantly turned away from the light. In studying other species of Pecten, many of which are highly colored, we find that the same condition exists, the lower right valve being white, or of a paler color than the left upper valve, which may be brilliantly colored: red, brown or yellow. An example of a striking contrast is *Amusium (Pecten) japonicum*, in which the upper valve is rich red, the lower, pure white. In the Spondyli, which are attached by the right valve, the lower valve also is white, or paler than the upper left valve, which is turned toward the light and is often highly colored. Fischer notes the difference in color of the valves in Spondyli, and states that an abyssal species of Spondylus has both valves blanched. This relation of the coloration to the amount of light received by the two valves in bivalves is more or less noticeable in the lower and upper side of univalves and is briefly considered by Tryon. Dr. Dall (16) considers the allied subject of the coloration, surface marking and thinness of the shells of abyssal species, in his interesting conclusions published in the Report of the Blake Mollusca.

Pecten magellanicus Gmelin (*P. tenuicostatus*, Mighels). A number of young specimens of this large species measuring from 2–6 mm. in height were dredged at several stations by the U. S. Fish Commission Steamer Albatross. They are entered as No. 62307 in the Smithsonian Institution Catalogue. Sharply-defined but quite small prodissoconchs, like those figured in *Pecten irradians*, mark the umbos of all well-preserved specimens. Fig. 38, p. 348 represents one of the smaller specimens. The early dissoconch as indicated by the lines of growth is similar in form to *Pecten irradians*, Pl. XXVIII, figs. 9–10, no ears having developed and there is a deep byssal notch in the right valve although it is slightly indicated in the adult. The byssal notch of the right valve, however, bears no teeth as in the other species described. The hinge line equals nearly the whole width of the shell as in *Pecten irradians*, Pl. XXVIII, fig. 12; but, as in that species, differs in this character from the adult. The hinge area on either side of the cartilage pit bears a wide hinge plate, sinuous in outline and marked by numerous flutings. The flutings are nearly perpendicular to the hinge line, but are slightly inclined toward the umbos. Although characteristic of the young, this hinge plate is wanting in the adult.

A similar hinge plate exists in *Pecten monotimeris*, Con., and it is described by Dall (16) in the young or adult of several species of Pecten, and in Pseudamusium and Dimya. This fluted plate, Dall considers as a form of dentition augmenting the strength of the hinge line (on the hinge of Pelecypods, etc., Am. Jour. Sc. Dec. 1889).

The right valve of *Pecten magellanicus* has a thin layer of well defined prismatic structure, fig. 39, and the prisms are larger than those observed in other species of Pecten. They are peculiar in being for the most part almost quadrangular, and are arranged with extreme regularity parallel to the lines of growth; but where slight fractures have induced irregular shell growth, they are polygonal as in other species of Pecten. The right valve in the young specimens studied seldom shows radiating striæ but they sometimes exist slightly emphasized in the last-formed portion of the shell, as series of disconnected knobs. The ventral ear of the right valve, on the contrary, bears coarse costæ crossed by imbricating lines of growth. In the adult, the radiating ridges of the right valve are much flatter and less accentuated than in the left upper valve. The left valve, fig. 38, after the earliest nepionic stages, which are smooth, is marked by a stage of concentric and radiating ridges both sharply defined and dividing the shell surface into sunken squares. Knobs or bosses ornament the intersection of the ridges. The structure seen here is a common form of surface ornamentation among fossil Aviculidæ. This peculiar marking of the early stage is very characteristic although limited in extent and ceases suddenly being succeeded by fine somewhat sinuous radiating ridges which are retained thereafter, and are characteristic of the adult.

Fig. 40.

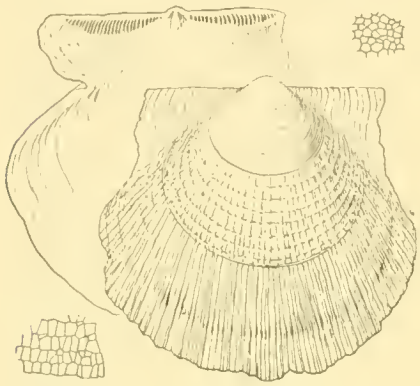


Fig. 39. Fig. 38.

Fig. 38.—Left and right valve of young *Pecten magellanicus*, showing fluted hinge plate byssal sinus, and marking of the left valve characteristic of the period of development. × 18 diam.

Fig. 39.—*Pecten magellanicus*, prismatic structure of right valve. × 90 diam.

Fig. 40.—*Pecten dislocatus*, prismatic structure of right valve. × 90 diam.

Original specimens in Smithsonian Institution, Washington (drawn by J. H. Emerton).

Some adult specimens of *Pecten magellanicus*, from the Georges' Banks, are interesting for a comparison with the observations on anatomical features of *P. irradians*. The species is well fitted for study on account of the size, adult specimens measuring 15 cm. or more in height. The adductor muscle is double and the two portions are strongly accentuated. The borders of the two portions of the muscle are free on their limits and at the point of insertion in the shell produce two well-marked impressions instead of a single slight one as in *Pecten irradians*. There is no posterior retractor muscle of the foot in this species; but it quite likely exists in the young, as that bears evidence in its shell, fig. 38, of being an active crawler. The foot is marked by two clefts, the distal one for crawling, the proximal one the seat of the byssal gland as in *Pecten irradians*. The mantle as in that species, has a thick marginal perpendicular wall, decreasing at the eared areas and thickly set with guard tentacles, extensible tentacles and eyes, indicating similar habits to those described in *Pecten irradians*. The gills, intestine, and reproductive body are also the same as may be observed in *Pecten irradians*.

Chlamys (Pecten) islandica, Chemn. sp., specimen No. 27294, Smithsonian Institution

catalogue, is a young individual 3 mm. in height. This specimen is figured in Pl. XXVIII, fig. 14, as viewed from the left side and Pl. XXVII, fig. 8, is the umbonal area more magnified, viewed from the right side. The prodissoconch is sharply defined and the umbos are directed slightly posteriorly. It bears concentric lines of growth, no indication of a byssal sinus and is homogeneous in structure. The succeeding dissoconch is yellowish-brown and in its early stages has a well-defined, prismatic layer in the right valve. In the oldest period of this young specimen no prismatic layer exists, the structure being lost thus early in shell growth. The left valve has a punctate structure as mentioned in some other species. The early nepionic stage as discerned by following the lines of growth is seen to be similar in form to the nepionic stage of *Pecten irradians*, Pl. XXVIII, fig. 9. The left valve is marked by a deep byssal notch, Pl. XXVII, fig. 8, the lower border of which bears teeth similar to those of *Pecten irradians* and these teeth exist also in the adult of *Chlamys islandica*. At the close of the smooth, early nepionic stage of *C. islandica*, we find radiating plications similar to those of the adult originating at a definitely marked area, Pl. XXVIII, fig. 14. New plications develop in succeeding growth between those first formed, instead of the first formed being the only ones built as in *Pecten irradians*. The hinge line is very long proportionately to the width of the shell as compared with the adult condition; the same feature being characteristic of the young of all the species described. The ears in this early stage are nearly equal, whereas in the adult the ventral (anterior) ear is characteristically much larger than the opposite or dorsal ear.

Pecten dislocatus, Say. A number of young specimens of this species are in the collections of the Smithsonian Institution, under the catalogue number 62278. They were dredged off the coast of the Carolinas at several stations. The specimens vary from 3 to 13 mm. in height. All the youngest show a prodissoconch like that of *Pecten irradians*, Pl. XXVIII, figs. 9–10. The prodissoconch bears fine concentric lines of growth, has no indication of a byssal notch and is not prismatic; also the umbos are directed posteriorly as in all this group. The right valve has in early nepionic stages a well-defined prismatic layer, fig. 40, p. 348, the prisms being of about the same size as those in *P. irradians* and *Chlamys islandica*, but smaller than those in *Pecten magellanicus*. Conversely, the left valve has no prismatic layer; but it has a very characteristic pitted structure in its early stages. The pits are not deep, but numerous and very closely related to one another. They disappear with the close of the smooth nepionic stage. A similar structure is described in some other species; but in none, unless *P. testæ*, is it as noticeable and clearly marked as in this species.

The early nepionic stage of *Pecten dislocatus*, as ascertained by following the lines of growth, which are particularly well defined in this species, is seen to be of the same form as that of *Pecten irradians*, Pl. XXVIII, figs. 9–10. No ears exist at this period and the hinge line in length equals the entire width of the shell. A deep byssal notch exists in the right valve originating with the close of the prodissoconch stage. In later growth plications in the shell originate suddenly as in *Pecten irradians*, Pl. XXVIII, fig. 12, causing by their introduction a marked stage as in that species. Ears also develop with succeeding growth and the hinge line gradually loses its great length proportionately to the

width of the shell. The base of the byssal notch bears a number of teeth like those of *Pecten irradians* and *Chlamys islandica*, but they are wanting in the adult.

Pecten testæ. In the Jeffreys collection, now in the Smithsonian Institution, there are two very young specimens of this species, catalogued as No. 62607. I saw them in Washington, but did not borrow them as I did specimens of the above described species. From a drawing made at the time (previous to my studies of other young Pectens) the upper left valve exactly agrees in form and is of about the same size as *Pecten irradians*, Pl. XXVIII, fig. 9. A prodissoconch like that of *P. irradians* and other species exists in my drawing of the specimen. The early dissoconch shell has no ears and is comparable to ancient forms of the Aviculidæ as discussed in considering the same period of development of *Pecten irradians*, with which it agrees in form as far as my drawing indicates. Minute, punctate structure of the dissoconch was observed in this species similar to that noted in *Pecten dislocatus;* but I cannot say whether prismatic structure exists although in all probability it does.

Specimens of *Pecten monotimeris*, Con., recently received from California, have a similar prodissoconch and nepionic stages to those described in *P. irradians*, as ascertained by following the lines of growth. In the nepionic stage, the right valve has prismatic cellular structure and the left valve punctate structure as in *P. irradians*, but as in that species these features are early lost.

XI. Genera allied to Pecten.

Of the genera here considered I have had only limited opportunities to study the young; for, as conchologists commonly pay little attention to the young of molluscs, it is a difficult matter to obtain early stages of genera not living in our own waters.

Hinnites, Pl. XXVI, figs. 3–4, is a genus closely related to Pecten, but as it has been described in section VII, I will give only brief supplementary notes at this point. It is shown, p. 324, that *Hinnites cortesi* is pecteniform and regular when young; later it solders one valve to a foreign body and with this change in habit assumes an irregularity of growth rendering its valves, especially the attached one, comparable to Ostrea in form. The form of the valves is ascribed to the condition of cemented fixation. The relation of Hinnites to Pecten I believe is directly comparable to the relation of Ostrea to Perna; the difference being that Hinnites in the nepionic and nealogic stages is free or byssated and then retains the ancestral Pecten features. It does not become attached and assume the ostrean irregular growth (wiping out early characters) until a comparatively late stage of development, Pl. XXVI, fig. 3. On the other hand, Ostrea is attached at the close of the prodissoconch period and at once assumes the ostrean form, by this means eradicating features which might otherwise render the early dissoconch growth comparable to the ancestral Perna or Perna-like form. The age at which fixation takes place varies somewhat in individuals, as may be seen in series of specimens of *Hinnites giganteus*. That species is instructive as showing how, in the development of the individual, the imbrications of the lines of growth in the nealogic pecteniform stage gradually become more and more produced, until in the adult they form spinous productions of the

valves. The spines of the left (free) valve are comparatively sharp and acicular, while those of the right (attached) valve are flatter and spathulate; though both forms of spines may be serially traced to the imbrications of the young, where they are alike in both valves.

Spondylus as a genus of attached Pelecypoda naturally draws attention in these studies. It is cemented by one valve and its irregular, inequivalvular shell, Pl. XXVI, fig. 1, has been ascribed to the conditions of cemented fixation (*vide* pp. 318 and 323). The camerated structure of Spondylus has been also considered and I wish here only to describe the young.

In the collections of the Boston Society of Natural History are specimens of *Spondylus asperrimus*, Sby., from the Pacific Islands, bearing the catalogue number 8494. The upper left valves of the specimens are produced on the hinge line as slightly developed ears and have a decidedly pecteniform aspect, as is characteristic of this valve in living and fossil Spondyli. The lower right valves which are or have been attached, are composed of highly irregular, concentrically rugose and spinous shell growth, as is also characteristic of species of this genus. One of the specimens of a right valve, however, is very well preserved up to the initial stages of growth. At the umbo of this well-preserved specimen of *Spondylus asperrimus*, Pl. XXVII, fig. 4, is a prodissoconch similar to that described in species of Pecten. The prodissoconch is rounded or oval in outline and is clearly marked off from the succeeding shell growth.[1] It is not sufficiently well-preserved to show lines of growth; but it has no byssal notch which exists, however, in the first stages of the succeeding dissoconch growth, as in Pecten, Pl. XXVII, fig. 9. The first nepionic stage of shell growth in Spondylus, as shown in the figure, is pecteniform. It has a long hinge line relatively to the width of the shell at that age, and a deep byssal sinus. As in the prodissoconch most of the lines of growth of this early stage have been worn off. At the close of the pecteniform stage the animal became soldered to a foreign body and the succeeding shell deposition, affected by the new condition of cemented fixation, has assumed the irregular and rugosely distorted growth characteristic of young Spondyli. In the first stages of the irregular growth, the byssal notch is soldered over, and eradicated in a similar fashion to that shown in Hinnites, Pl. XXVI, fig. 3. A prodissoconch and nepionic stage similar to that described in *Spondylus asperrimus*, has been observed also in specimens of *S. croceus*, Chemn. and *S. variegatus*, Chemn. sp.?, at the New York State museum; and in *S. ducalis*, Chemn. and *S. varians*, Sow., at the Peabody Academy of Science, in Salem.

The above description of the development of the shell of Spondylus is directly comparable to what has been described in the shell of Hinnites. Both valves before fixation are pecteniform in these genera; as soon as attached the lower valve loses this early existent, ancestral feature and assumes the irregularity characteristic of attached Pelecypoda with of course the peculiar order of irregularity normal to Spondylus or to Hinnites. As the lower valve becomes irregular and distorted, the upper valve in both genera, acting in sympathy, becomes irregular also; but, as previously claimed, the dis-

[1] A specimen of a left valve of a young Spondylus, in the Smithsonian Institution collections, catalogue No. 62242, shows a prodissoconch like that described above in a right valve. It is rounded, with slightly developed umbos. Its limits are marked off from the succeeding dissoconch as in Pl. XXVII, fig. 4, of a right valve of *S. asperrimus*.

tortion of the upper free valve is seldom as great as the distortion of the lower cemented valve. Specimens of *Spondylus imperialis*, Chemn., in the Society's collections, show the remarkable condition of being perfectly equivalvular. Both valves have ears on the hinge line and though spinous, both are equally so. The right valve has no triangular hinge area or talon and the umbos of the two valves are closely related. Studying these shells, I found no evidence that they had been attached during any period of their growth. With this freedom from fixation we have, therefore, an equivalvular shell which is a wide departure from the typical condition of the genus.

The conclusion arrived at that the free valve of attached, cemented Pelecypods is least modified and therefore retains more of the ancestral characteristics, which are nearly or quite eradicated from the cemented valve (section VII), thus finds strong support in Spondylus. In many figures of fossil Spondylus, published by MM. d'Orbigny and Pictet, (also see Pl. XXVI, fig. 1), we find striking dissimilarity in the two valves, the attached one being always the most modified. The free valve which is least modified retains in a marked degree, especially in the young, characters which are traceable to the Pectinidæ, from which the Spondyli have doubtless evolved. I have not dissected a Spondylus; but from published notes gather that this genus is closely connected with Pecten by anatomical features.

Plicatula is a genus placed next in kinship to Spondylus, the anatomy being similar according to authors. Some very young shells of *Plicatula marginata*, Say, Pl. XXVII, fig. 5, from the Miocene Tertiaries of North Carolina present features of interest. A distinct prodissoconch, similar in form to that of Pecten and Spondylus, exists. It is rounded with slightly developed umbos which are directed posteriorly. The specimens, as shown in the figure, bear a considerable resemblance to young oysters of a similar age; and as it may be thought that a mistake has been made in the identification, I may say that they show the typical teeth of Plicatula, also series of specimens have been traced from the very young to the mature condition. The prodissoconch umbos in specimens of Plicatula, when attached to the object of fixation, Pl. XXVII, fig. 5, point to the right of the observer viewing them from above, whereas in Ostrea, Pl. XXV, figs. 1–5, they point to the left, which is due to the fact that Plicatula is attached by the right valve, whereas Ostrea is attached by the left. In both genera, the prodissoconch umbos are directed posteriorly relatively to the anatomy which is known directly or by analogy to have existed at the close of the prodissoconch period.

The early nepionic stage of Plicatula, Pl. XXVII, fig. 5, is very similar in appearance to a young oyster, as stated. The lower right valve is flat and closely related to the object of fixation, while the upper left valve is convex.[1] No byssal notch is discoverable in the earliest stages of dissoconch growth, and this feature, together with the form of the valves, indicates that Plicatula became permanently attached at the close of

[1] It has been observed by authors, that the upper valve of fixed Pelecypods, such as Ostrea and Anomia, also univalves, as Crepidula, frequently simulates the outlines of the object of support, ridges, knobs, etc., on the foreign body, being perfectly reproduced in the free valve. The most striking case of this, I have seen, is in a finely preserved specimen of *Plicatula marginata*, from the Tertiaries, in which the free valve reproduces with beautiful exactness the structure of a Bryozoön over which the attached valve was growing. Not only a general copy is made, but each cell is outlined in the upper valve of the Plicatula.

the prodissoconch stage, as is conclusively shown to be the case with oysters. Adult *Plicatula marginata*, is deeply plicated; but the plications, as in plicated oysters, do not originate until the shell growth extends beyond the limits of the object of fixation.

Plicatula, taken in connection with the preceding genera, is a valuable proof of the correctness of the conclusion that cementation destroys indications in the shells of Pelecypoda of their ancestral relationship. Pecten, Hinnites, Spondylus and Plicatula may be serially connected in the order indicated by a study of the shell, and from what I can gather, the anatomical features would present a similar series. Using some license so as to express it graphically, one may say: solder a Pecten when partly grown and the succeeding growth is irregular, forming the genus Hinnites, Pl. XXVI, figs. 3–4; solder a Pecten at a much younger period and the succeeding growth is irregular, forming the genus Spondylus, Pl. XXVII, fig. 4; solder a Pecten at the close of the prodissoconch stage, before any dissoconch growth has taken place, and the succeeding growth is irregular, forming the genus Plicatula, Pl. XXVII, fig. 5. In all, the irregularity of growth commences with the introduction of the cemented period. Spondylus is probably a branch from Pecten through the intermediation of Hinnites, which unquestionably is closely akin to Pecten. So near are Spondylus and Hinnites, that Stoliczka says some fossil forms, first considered as Spondyli, have since been transferred to Hinnites.

Brief studies of Lima have been made. Lima has a perpendicular mantle wall like that of Pecten which is shown to be so actively functional in swimming, and it probably subserves the same purpose in Lima, as the swimming of that genus, described by Dr. Jeffreys (see Tryon), is performed similarly to that of Pecten. This difference exists, however; Lima swims with the plane of the edges of valves perpendicular, whereas in Pecten they are horizontal while swimming. From the shape of the mantle walls and shell, also from the description of the swimming movement, it appears that in Lima the excurrent flow of water which propels the animal all takes place through one eared area, the ventral, instead of alternately from either ear as in Pecten. In the species of Lima examined, there were no guard tentacles on the free borders of the mantle walls as in Pecten, Pl. XXVIII, fig. 4, but Jeffreys' description of Lima includes such organs. The marginal tentacles at the base of the perpendicular wall are thick and numerous. Dr. Jeffreys describes them as twining actively and presenting a tenacious prehensibility, grasping the fingers when approached toward them. This prehensibility I have described in Pecten though it is there less marked in degree. The gills of Lima have the reflected portion of the filaments equal in length to the direct portion, and the tip of the reflected portion of each lamina is again reflected, presenting an abbreviated additional lamina.[1] The gills of Lima differ from those of Pecten in that the separate filaments are joined by bars which form a direct concrescence of the several filaments instead of by the interlocking of ciliated processes, as in Pecten; and in this character Lima agrees with Ostrea.

A young *Lima elliptica*, in the Jeffreys' collection at the Smithsonian Institution, shows a well-marked prodissoconch. In a drawing which I made at that museum, Pl. XXVII, fig. 6, the prodissoconch is sharply marked off from the succeeding dissoconch, and it

[1] In *Pecten irradians*, the tip of the reflected filaments is bent back on itself slightly, Pl. XXIV, fig. 12, indicating the initial stages of such an abbreviated additional lamina. Lacaze-Duthiers also observed such a brief reflection in the outer filaments of Anomia.

has well-developed umbos. The succeeding dissoconch is limaform, but no prismatic structure was observed as in young Pectens; it may, however, exist in well-preserved specimens.

XII. Anomia. Anatomy and Habits.

Anomiæ freely attached themselves to the glass slides in my drain-pipe traps and therefore I had an opportunity to study the young under this favorable condition with transmitted light. The species is *Anomia glabra*, Verrill, figs. 41–42, which is abundant in the shoal waters of Buzzards Bay, often covering shells and stones as thickly as do oysters.

Anomiæ have not in the same degree as oysters the power of resisting drying which is so characteristic of that mollusc, and rarely set at points which are long exposed at low tide. They grow rapidly and some specimens attached to glass slides measure 25 mm. in height, the result of the summer's growth. These almost equal the adult in size as the latter rarely exceed 40 mm. Examining Anomiæ where a number are attached to a single rock or shell, it will be found that the longer axes of the specimens in most cases are nearly parallel, the reverse of the condition of oyster spats, where the axes point at every angle in the plane of the surface of attachment. This parallel arrangement in Anomia seems to bear a relation to the direction of strongest currents, the animals arranging themselves during their early locomotive stage in the plane of least resistance and afterwards becoming permanently fixed in this position. On the other hand, oysters which have no crawling locomotive stage, pay no attention to prevailing currents in their position of fixation. A marked case of animals arranging themselves with regard to currents was observed in *Crepidula fornicata*, Pl. xxiii, fig. 22. Large numbers of colonies were found at Buzzards Bay like the figure in which all the individuals were headed one way. This arrangement in one plane does not always hold in Crepidulas as they may be arranged at different angles; in such cases we may reasonably suppose that no strong prevailing current existed in the location where the animals grew.

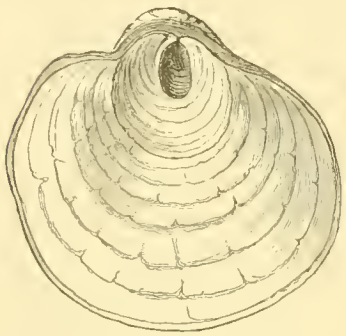


Fig. 41.

Fig. 42.

Fig. 41. Adult *Anomia glabra* viewed from the right, lower side; natural size.

Fig. 42. The same in profile view. (From Binney's Gould.)

Anomia was formerly considered as related to Brachiopods, but such a connection has long been disproven. Forbes and Hanley and Lacaze-Duthiers compared Anomia to Pecten; but notwithstanding this, a close relationship of the genus to Ostrea has been as a probability quite generally entertained. This assumption appears founded on a certain similarity of the shell of Anomia to an oyster, especially a young oyster. Anomia belongs to the same broad group as the oysters, as proven by features of anatomical and shell structure; but it is more nearly related to Pecten than to Ostrea. Previous studies have shown that the form of the shell in Pelecypods is often highly modified by

special conditions, as the cementation of a valve, or by anatomical features and habits of the individual. I think therefore that the peculiarity of the shell in Anomia may be considered as an adaptation to its environment[1] and not due to any genetic connection of the group. On this question we have the support of the conclusions of Professor Lacaze-Duthiers, who in his well-known paper on *Anomia ephippium*, L., says: " . . . l'ossicule de l'Anomie est un byssus, et toutes les anomalies sont la conséquence de la position de l'animal sur la côté droit, et de la soudure du byssus aux corps étrangers." His studies were anatomical, based on the ambiguous adult and it is my pleasure as a result of studies of the young, to be able to show conclusively the correctness of some of the deductions of the eminent French investigator.

The youngest specimens found alive on glass slides were about the size of Pl. XXIX, figs. 5–6. At this age and up to a considerably later period of growth, the young are freely locomotive, crawling actively at intervals by prolongation of the highly developed foot. The lines of growth in fig. 6 indicate that, when very young, the byssus was on the extreme margin of the valves; but in this figure the byssal sinus has already become sub-central in position and partially enclosed by the growth of the right valve. At this age the byssal fixation is only maintained a part of the time, or perhaps more correctly speaking the byssal attachment may be said to be voluntarily and frequently abandoned. The byssus of this early period is composed of a series of bundles of threads which flatten against the surface of the glass as seen from the right side through the glass to which it is attached. The byssal hold at this age is an act of volition on the part of the animal, as if paralyzed with cocaine they may be easily washed off a glass slide by a stream from a pipette, whereas in the normal condition they cannot be dislodged by any force short of scraping. The cocaine treatment is a good method to employ in collecting very young Anomiæ attached to shells, rocks, etc., because if scraped off, the lower valve, which, in this species, is of extreme tenuity, is almost certain to be destroyed. When older the byssal attachment becomes permanent by the calcification of its tip.

A young Anomia viewed from the left side is shown in Pl. XXIX, fig. 1, and the reverse or right side of the same individual seen through the glass to which attached is shown in fig. 2. The relations of these views to one other and to the adult described by Lacaze-Duthiers are of much interest. The single adductor muscle of the valves, *ad*, figs. 1–2 (also in the diagram Pl. XXIX, fig. 3), is situated a short distance below the heart, *h*. It is very small relatively to the size normally found in Pelecypods, a fact having important bearings. This is the only muscle indicated in the left valve which passes to the right valve or which finds its counterpart in that valve and the same condition exists in the adult. A large byssal muscle, *bm*, fig. 1, inserted in the left valve passes to the foot and byssus, the calcified attachment of which is shown at *bs*, fig. 2. The byssal muscle at its insertion in the left valve has a peculiar sinuosity in its posterior face which is not understood. A posterior retractor of the foot, *pr*, figs. 1 and 3, is attached to the left valve a short distance from the byssal muscle and close to, but separated from, the adductor. It is somewhat remarkable that the posterior retractor lies on the ventral border of the adductor, as the typical position of the posterior retractor in Pelecypods

[1] In Anomia, the shell itself is not cemented to foreign bodies as in the ostrean forms considered; the attachment is by means of the calcification of the byssal tip, and is not to be confounded with the cementation of one valve.

is on the dorsal border of the adductor, as in Mya and Modiola, Pl. XXV, figs. 9–10. The fibres of the posterior retractor pass forward to their insertion in the foot and merge with the byssal muscle as distinctly seen from the left side. An anterior retractor of the foot, *ar*, figs. 1–3, is inserted in the left valve near the umbonal region. Whereas in the young the adductor, posterior retractor of the foot and byssal muscles are distinct and separate, in the adult they are rendered ambiguous by being in close contact with one another, although making three separate scars in the left valve of the shell. The true nature of the muscles of the adult, as described by Lacaze-Duthiers, is therefore seen to be clearly apparent in the young.

In young *Anomia* attached to glass slides where the action of parts may be observed through the very translucent valves, it is noticeable what an active part the byssal and retractor muscles of the foot take in pulling down or closing the upper, left valve, on account of being attached distally by means of a calcareous union to the object of support. This is rendered clear by comparing Pl. XXIX, figs. 1–2 with the diagram fig. 3. By the action of these muscles the upper left valve is brought in close contact with the object of support, so that it conforms to the surface as does the shell of a Crepidula, or limpet, under somewhat comparable conditions of fixation. In correlation with this changed function of the retractor muscles of the foot, and byssal muscle in *Anomia glabra*, it is important to notice that the adductor muscle is very small and the lower right valve extremely thin, a mere veil of tissue in the young, so that it would be almost functionless for protection, if the young could be exposed to attack from this side, which however is not the case. It is thus evident that the byssal muscle and the anterior and posterior retractors of the foot in the young are together pseudo-functionally an adductor in their action and as a correlation a reduction of the actual adductor and lower valve has taken place. This condition of affairs is evidently brought about by the position of the parts relatively to the surroundings and is ascribed to them. Lacaze-Duthiers ascribes the absence of retractor muscles of the byssus and foot on the right side to atrophy and loss from disuse. The great size and amalgamation of the byssal muscle and posterior retractor he ascribes to the changed directions of the fibres and the functional activity in the changed position, perpendicular to the object of leverage. He may have intended the comparison of the muscles to an adductor which I make, but it is not so understood from his text.

The young Anomia opens its shell by the lifting of the upper valve alone and it has considerable forward and backward as well as lateral motion due to its peculiar method of attachment. When quietly feeding, the anterior retractor of the foot, *ar*, Pl. XXIX, figs. 1 and 3, may shorten and this muscle being inserted at the byssal region of calcareous fixation the animal responds by moving backwards; conversely, if the posterior retractor, *pr*, figs. 1 and 3, shortens, the shell is moved forwards, as will be understood by considering the diagram, fig. 3. In the adult there is little or none of this forward and backward motion, as the byssal plug is closely surrounded by shell growth and also the position of the posterior retractor is changed so that it could hardly bring about such a movement.

The foot in adult *Anomia glabra* is a small reduced organ; but in the young it is very large and active, Pl. XXIX, figs. 1, 2 and 5. The base of the foot is marked by a deep

cleft up to its extreme distal portion and the very young, fig. 5, in crawling extends and flattens it against the object of support in a prehensile disc-like fashion, as described in *Pecten irradians*. After the animal becomes permanently fixed, figs. 1 and 2, the foot was not observed to extend beyond the margins of the valves; but it was constantly moved within the mantle walls in a sinuous manner. The foot is of large volume embracing the byssus at its point of attachment to the glass slide, fig. 2, and the open cleft of the foot makes a V-shaped space immediately in front of the byssus; but soon the walls of the cleft are in contact. The byssus is thus seen to originate from a cleft in the base of the foot as in ordinary byssated Pelecypods.

The upper proximal face of the calcareous plug of adult Anomia is marked by lines parallel to the longer axis of the shell and similar lines are noticeable in the basal portion of the plug, *bs*, where attached to the glass, Pl. XXIX, fig. 2. The lines are made up of parallel series of amalgamated, calcareous, discoid points seen in the fore part of the byssal attachment in the figure. The discoid points are directly comparable to the discoid points of fixation of separate byssal threads observable in Pecten, Mytilus, etc., the difference being that in Anomia the several points are calcified. In the young we have therefore the fullest substantiation of Lacaze-Duthiers' homology of the plug of Anomia with the byssus of other Pelecypoda; for we can actually see the byssus coming from the cleft in the foot and the separate byssal threads amalgamating to form the calcareous plug.

The palps of Anomia, Pl. XXIX, figs. 1–2, originating close to the umbos pass to the right of the anterior retractor muscle and to the left of the foot and terminate in close relation to the anterior limits of the gills. They are marked by plicated ridges on their posterior borders. The coils of the intestine were not followed, being hidden in the dark brown liver follicles which cover the greater part of the body mass. The liver presents two regions of densest portion separated by a lighter portion in which there are few follicles as shown in the figures. The rectum passes over the dorsal border of the adductor muscle and is produced to a considerable extent into the cloacal chamber, the anus, *a*, being free, figs. 1–2, and in the adult a similar condition exists. A highly developed cæcum, *c*, fig. 2, as in the adult, is prolonged in a curved line from the body mass past the ventral border of the adductor and to the right of the gills ending blindly in the cloacal chamber. It is clear in the young as it is not complicated by the existence of the reproductive gland found in the adult.

The heart, *h*, consists of a ventricle and probably two auricles as in the adult,[1] but the heart in the young is surrounded by a pericardium, whereas in the adult Lacaze-Duthiers says that this is wanting. He expresses the belief that the pericardial walls may have become united with the walls of the heart proper and in view of its early existence this is a reasonable explanation of its disappearance. On the left side a large vessel, *v*, fig. 1, passes from the heart in front of the byssal muscle and to the gills of the left side; another vessel, *v*, passes between the adductor muscle and retractor of the foot. These are similar to those of the adult after Lacaze-Duthiers. Other vessels ramify in the mantle as described in young oysters. The pulsations of the heart are variable. In fig. 1 were counted eighty

[1] I express this with a degree of caution, as I did not actually observe in the young the second auricle described in the left side of the adult by Lacaze-Duthiers; but other parts being so coincident with his figures and description, its presence is assumed; as he says it is with difficulty seen in the adult.

to eighty-four heart-beats per minute in several counts. At other times in the same specimen forty-four, forty-two and twenty-one beats were counted; but these were much below the normal. In a younger specimen sixty beats were recorded at several counts. Watching the heart it may be seen to stop for a considerable time and then begin again first beating slowly; but soon getting up to its normal rapidity. The cessation of pulsations may be induced by disturbing the animal and the pulsations are most regular and active while the Anomia is quietly feeding with the mantle extended.

The gills in very young Anomias the age of Pl. XXIX, fig. 5, are simple, straight filaments not joined to one another in any way and the tips not yet recurved upon themselves. (Compare with young oyster gills, Pl. XXIV, fig. 6.) Dissecting specimens of the age of Pl. XXIX, fig. 1, it was found that the inner pair of gill plates had their filaments reflected dorsally and the filaments of the opposed lamellæ were joined to one another by the concrescence of their dorsal borders. The two outer gills, on the other hand, had their filaments reflected upon themselves; but the recurved part equalled only about half the length of the direct part. The same relation of filaments exists in the adult gill diagrammatically shown in Pl. XXIV, fig. 11. The individual gill filaments in specimens of the age of fig. 1, as also in the adult, are joined to one another by concrescence at the tips of the dorsally reflected borders; but they are not joined to one another at other points. Further the filaments have not the nodular ciliated processes characteristic of the gills of Pecten. Therefore, the gills of Anomia have filaments which are individually free to a somewhat remarkable extent. This is interesting as showing an almost primitive condition in one organ when other organs are so modified as to render Anomia one of the most highly specialized of the Pelecypoda. The gills are connected with the body by two membranes, *s*, Pl. XXIX, figs. 1–2, which have been described (Tryon) as falciform. These membranes are attached to the adductor muscle, to the body anteriorly from that point and to the mantle wall posteriorly to the adductor. The posterior attachment is not shown in Lacaze-Duthiers' figures; but it is a marked feature in the young of *Anomia glabra*. A large foramen exists in each of these membranes. The foramen of the left membrane, fig. 1, is the larger and my attention was attracted to it by seeing the extensible and restless foot prolonged across the body and thrust through this hole. In fact it was a favorite act with this individual at least, for after noticing it I frequently found the foot thrust through the foramen. The foramen in the right gill membrane, fig. 2, is smaller than that in the left. The membranes extend in a free curving line to the posterior extremity of the gills. The gills are capable of considerable motion and frequently in the young may be seen protruded beyond the margins of the valves and even beyond the borders of the extended mantle lobes as well. The length and width of the several gills is different as pointed out by Lacaze-Duthiers. In comparing Pl. XXIX, figs. 1–2, it is seen that the gills on the left side are much longer and broader than on the right side on which the animal rests, a feature which, as Lacaze-Duthiers said, is doubtless connected with the conditions of fixation.

The mantle of Anomia presents peculiarities which are necessitated by the abnormal position of the byssus. The mantle lobes are free except for a short distance on the ligamental area (observed in an adult) where the lobes of the two sides are confluent. The right lobe has a deep re-entrant fold where it surrounds the byssus, shown in Lacaze-Duthiers' figures and slightly indicated in Pl. XXIX, fig. 2. The margins are fringed

with active extensible tentacles which are in constant motion. The tentacles of the young are pigmented with black in scattered spots and bands of color which are arranged at right angles to the longer axis of the tentacles. I did not observe radial muscles in the mantle of Anomia similar to those described in Ostrea and Pecten, and if they exist as they probably do, they are inconspicuous.

XIII. Anomia. The shell.

Professor Morse published a brief account of some extremely young shells of Anomia in which he showed that an early, probably "dimyarian" shell precedes the characteristic Anomian form of shell. He also showed the initial stages of the byssal notch. The specimens studied, judging from his description and a comparison with my own observations, were the young of was *Anomia aculeata*, Gmelin.

In *Anomia glabra* an ovally rounded, nearly equivalvular prodissoconch exists at the umbos of perfectly preserved young specimens, Pl. xxix, figs. 4–6. The prodissoconch in this species is opaque, of homogeneous structure, bearing fine concentric lines of growth, and the umbos which are nearly central are directed slightly toward the posterior end of the shell.[1] In this position of the umbos my observations differ from those of Professor Morse as he says the umbos are nearer the anterior margin of the shell. The left prodissoconch valve of *Anomia glabra* has no indication of a byssal notch but the right valve has a notch on its ventral border as shown by the lines of growth in Pl. xxix, fig. 6. It is therefore seen that at this extremely early period Anomia is already capable of forming a byssal attachment, and crawled on the right side with the foot extended at this area. The shell evidently lay on one side as observed by Morse. A byssal notch in the prodissoconch is a point in which Anomia differs from the byssated Pelecypods which have been so far discussed. In Perna, Avicula, Pecten and Spondylus, Pl. xxvii and xxviii, a byssal notch is indicated in the first stages of the dissoconch growth; but no trace of a notch exists in the prodissoconch.

The dissoconch growth of the left valve of *Anomia glabra* in its early stages, Pl. xxix, fig. 4, is at first nearly round, but slightly larger on the ventral side. It is thin, translucent, has a highly polished surface and bears numerous, delicate lines of growth, but shows no prismatic structure. An older specimen of a left valve, Pl. xxix, fig. 5, is less rounded, its faster ventral growth having produced a bulging in this direction which seems to be characteristic of specimens of this age. Whereas in fig. 4, the prodissoconch is on the anterior border of the valve and projects slightly beyond it, in fig. 5, shell growth is taking place in front of the prodissoconch, which is the primitive umbo of the valve, and in succeeding growth this feature is carried still farther as seen in fig. 8, so that in the adult the initial umbo is pushed in quite far from its original position on the anterior border of the valves. As growth continues from the stage fig. 5, the shell becomes more and more rounded, rapidly assuming the form characteristic of the adult. The young is so highly polished that the shell well deserves the popular name silver-shell which it bears.

The right valve at a very early period, Pl. xxix, fig. 6, differs much from the adult

[1]The umbos are directed posteriorly so slightly in Anomia that it is not a marked feature as in Ostrea, Perna, Pecten, etc., in which the umbos of the prodissoconch are more inclined toward the posterior region of the shell.

and is less highly modified. The initial stages of dissoconch growth commence on the free border of the prodissoconch valve; but succeeding shell deposition is extended posteriorly and then ventrally more and more, as may be seen by following the lines of growth, figs. 6–7, until finally a deep almost enclosed sinus is formed around the byssus, as shown in the figure. At this stage it is desirable to compare the right valve of Anomia, fig. 6, with my figure of the first stages of dissoconch growth of Pecten, Pl. XXVIII, fig. 10. In both, a deep and somewhat comparable notch is formed by the existence in one case of a byssus and in the other of a highly active foot; both organs affecting the form of the valve by causing a local retraction of the mantle and thus putting an obstacle in the way of shell deposition at that area. We see in the comparisons of these figures the verification of the statement made by Forbes and Hanley nearly fifty years ago that "the perforation in one of the valves of Anomia is chiefly a greater extension of the auricular sinus in Pecten." In later growth the ventral border of the valve surrounds the byssal notch in an increasing degree until soon it is completely enclosed. The lower valve is peculiar in that the mantle border of the umbonal region deposits shell around the prodissoconch, enclosing it by degrees and partially covering its umbonal portion as shown in Pl. XXIX, figs. 6–7. This is due to the fact that the primitive umbos recede from the shell border, being pushed back by the peripheral growth of the valve as seen viewed from the left side in Pl. XXIX, figs. 4, 5 and 8. When the byssus in young Anomia is nearly or quite surrounded by the growth of the right valve as in Pl. XXIX, fig. 2, the foramen is very small. In the adult, fig. 41, p. 354, on the other hand, the foramen of the right valve is many times larger and to accomplish this increased size of the hole an extensive resorption of the shell has taken place. During this resorption, lines of growth which were continuous when young become separated and may be traced on either side of the foramen, as in the figure cited.

The lower right valve in the young does not equal the size of left upper valve which overhangs its border by a considerable amount, Pl. XXIX, figs. 6 and 2; it is also of excessive thinness and so delicate that great care is required in handling not to injure it. The right valve shows the most beautiful, prismatic structure of which it is entirely composed in early stages, and it is so transparent that the organs can be seen as through a glass film. The extreme reduction of the lower valve in young *Anomia glabra* is evidently correlated with its conditions of environment. The byssal and retractor muscles are functionally active in drawing down the upper valve, and when that valve is closed the lower valve is completely protected. The reduction of the true adductor muscle as described and the thinness of the right valve are doubtless correlated; for, on account of its delicacy, the strong action of a normal-sized adductor would certainly break the valve. At this early period the right valve truly seems like a disappearing organ. In later growth the right valve increases in thickness and frequently extends beyond the object of support, but it does not acquire the thickness and solidity of the left valve.

I have stated that the right valve in young *Anomia glabra* is wholly composed of prismatic cellular tissue. This structure predominates throughout life in this valve, and in the adult the right valve entirely consists of prismatic cellular tissue with the exception of a thin layer of whiter porcellaneous tissue which surrounds the byssal foramen and point of insertion of the adductor muscle. The left valve, on the other hand, does

not have a prismatic layer at any period in the life of the individual; but is sub-nacreous excepting for a small area around the point of insertion of the muscles, where as in the right valve there is a deposition of porcellaneous tissue. This difference in the structure of the two valves is a remarkable feature and occurs in related genera, for I have shown that a thin prismatic layer exists in the right valve of young Pecten and in the right valve of young Ostrea but not in the left valve of either genus in early stages.

I have not found any published observations of prismatic structure in *Anomia glabra*, but Carpenter, in his second paper (1848), on shell structure, stated that a thin external prismatic layer exists in *Anomia ephippium;* but is early worn off. In this connection, an interesting point is recorded in one of Dr. C. A. White's papers,[1] that among Tertiary fossils it is rare to find a right valve of Anomia although left valves are abundant. He ascribes the loss of right valves to their fragility owing to their prismatic composition. On the other hand, a number of species of European Tertiary Anomias in the collections of the Museum of Comparative Zoölogy have both valves equally preserved. A very thin layer of prismatic tissue exists in the right valve of *Anomia ephippium*, as observed in specimens kindly sent me by Dr. Dall; but it does not exist in the left valve of that species, both valves being composed wholly or for the most part of sub-nacreous tissue, with the addition of porcellaneous tissue around the muscular insertions as in *Anomia glabra.* The difference in the structure of the right valve of *Anomia glabra* makes a good specific distinction, which separates that species clearly from *A. ephippium*, which it approaches very nearly in external form.

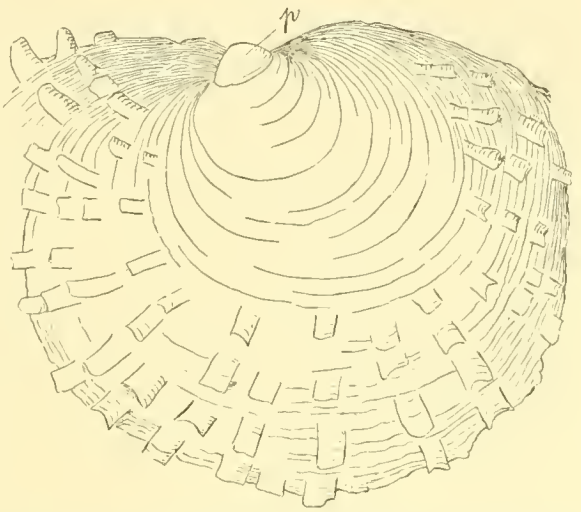


FIG. 43. Young *Anomia aculeata*, tip of left valve, *p*, prodissoconch, succeeded by early smooth and later spinous dissoconch growth. Cohasset. ×60 diam. (Drawn by the author.)

Young specimens of *Anomia aculeata*, Gmelin, fig. 43, were collected at Cohasset and Beverly, Mass. A yellowish prodissoconch exists at the umbos. The left valve of the prodissoconch has a slight sinuosity which corresponds with the comparatively deeper byssal notch in the right valve, whereas no sinuosity of the left valve and a shallower notch in the right exists in the prodissoconch of *Anomia glabra*, Pl. XXIX, figs. 4–8. This feature is shown in fig. 43, but is more marked in degree in younger specimens. The prodissoconch of *A. aculeata* is ovally rounded in outline with fine concentric lines of growth and umbos which are nearly central but directed slightly posteriorly as in *A. glabra.* The succeeding dissoconch growth of *Anomia aculeata* is chalky white, of somewhat irregular growth; and not polished or as translucent as is *A. glabra.* The left valve of the dissoconch does not perpetuate the sinuosity of the prodissoconch valve. This valve is smooth for a brief period and then the plications and spines characteristic of the species are commonly introduced. I say commonly, for associated specimens are frequently wanting in the spinous character, although unquestionably belonging to the same species. The right valve of the dis-

[1] Non-marine Fossil Mollusca of North America, Washington, 1883, p. 16.

soconch of *A. aculeata* has a growth similar to that described in *A. glabra;* but is chalky white and much thicker than in that species. The right valve is wholly or for the most part composed of prismatic cellular structure whereas that tissue is wanting in the left valve as in *A. glabra.* My observations of the young and adult lead me fully to concur with Professor Verrill who says that he believes this species is perfectly distinct from *Anomia glabra.*

In regard to the affinities of Anomia, it is closely related to Placuna and many intermediate forms may be traced as noted by authors. The anatomy of Placuna is essentially like that of Anomia; but the mantle border has a curtain like Pecten (Tryon). The shell of Placuna is composed of fine nacreous layers, but in the young I have found traces of prismatic cellular tissue in the right valve. This tissue was very thin and limited in extent on account of being worn away, but existed in patches. Woodward (79) mentions that, when young, Placuna has a byssal sinus in the right valve and I have found young specimens which show an enclosed byssal plug like that of Anomia, as described in section XVI. Anomia, anatomically and in shell structure, is much more nearly allied to Pecten than to Ostrea. It is probable that Anomia was derived from the Pectinidæ from the Amusium or Hemipecten group, for the latter resemble Anomia in having thin nacreous shells. In considering Hemipecten, Zittel remarks that Jurassic species of Placunopsis are probably confounded with Hemipecten, thus inferring a close similarity in the two genera. Placuna was probably derived from the early Anomiadæ as all evidence points toward an ancestry in that group. The geological appearance of these groups accord with their inferred zoölogical affinities as I have described them. That such a highly modified form of shell as Anomia could have been derived from the Pectens is more easily believed when we see how highly modified are Pedum, Hinnites and Spondylus which are more direct derivatives of Pecten.

XIV. Studies of a few other Genera.

The genera so far studied are all linked in one great group of the Aviculidæ and their allies (see table, section XVI), by characters of anatomy and shell structure which connect the several members. The genera thus referred to are Ostrea, Gryphæa, Exogyra, Perna, Avicula, Monotis, Pseudomonotis, Cassianella, Vulsella, Pecten, Spondylus, Plicatula, Lima, Anomia and Placuna. I now wish to consider the young of some genera belonging to other groups of Pelecypoda distinctly removed from those previously considered and not always closely connected with one another. Figures of the adults of most of the species described in this section are to be found in the works of Verrill and Gould.

The groups, previously studied, have been characterized by possessing *prodissoconchs of homogeneous laminar structure, but not prismatic, and with umbos directed posteriorly.* The succeeding dissoconchs have been shown to be markedly different in form from the prodissoconch, and in the earliest stages at least are characterized by *well-defined, prismatic, cellular structure,* either in both valves or the right valve.[1] In all gen-

[1] The change from homogeneous to prismatic structure was not observed in the fossils described or in Spondylus and Lima, but these genera are so united with groups that do show it, that the absence of the feature in the few specimens observed need not be considered in this connection.

era now taken up, excepting the Unionidæ, two marked features of difference occur as compared with those previously studied. The *prodissoconchs are directed more or less anteriorly*, and the succeeding dissoconchs are *not characterized by prismatic cellular structure.*

The Pelecypoda is a class in which it is very difficult to find binding characters on which to make systematic divisions. The direction of the prodissoconch umbos and the condition of prismatic structure in the succeeding dissoconch, I am aware, is not wholly confined to the Aviculidæ and their allies, but these features are characteristic of the whole of that group and are not together characteristic of any other group so far as known, excepting, possibly, the Unionidæ. A thin, but well-defined, prismatic layer exists in *Pandora rostrata*, Lam.; a prismatic layer also exists in the deeper-seated portion of the periostracum of *Solemya mediterranea*, Lam., and it has been observed in limited patches in young *Ensis viridis*, Say. Carpenter observed the prismatic layer in the two former genera and mentions finding traces of it in other genera, but he was impressed with the fact that it is a marked feature in the group of the Avicnlidæ and allies.

Mytilus edulis, L. This mollusc belongs to one of the oldest families of the Pelecypods extending back to early palæozoic times. It is therefore interesting to know the conditions existent in the young shell. In Pl. XXIX, fig. 9, it is shown that a well-defined prodissoconch, *p*, exists which is yellowish-brown and marked by fine concentric lines of growth. The form of the prodissoconch is evenly rounded and it has well developed umbos which are directed anteriorly. The succeeding dissoconch growth of Mytilus is sharply marked off from the prodissoconch stage by its changed form and color. In form the dissoconch has already acquired features characteristic of the group to which it belongs, though not of the genus itself. The hinge line is produced posteriorly in an arched line and anteriorly the lines of growth are curved inwards toward the umbonal area, but they are not crowded closely as in the adult or any species of the genus. The shell at this age reminds one strongly of forms seen commonly in the Modiomorphas, palæozoic kindred of the Mytilidæ. In color the dissoconch is distinct from the prodissoconch. Whereas the latter as stated is yellowish-brown, the dissoconch is characterized by the violet color characteristic of the adult. The transition from brown to violet color in Mytilus is as sharply defined as is the change from homogeneous lime in the prodissoconch of Ostrea to the prismatic structure of the succeeding dissoconch, fig. 27, p. 314. Specimens of *Mytilus edulis* of the light horn colored variety of course do not show this change to violet with the introduction of the dissoconch period. No trace of prismatic cellular tissue has been found in the shell of Mytilus or other member of this family at any period of growth, but a well defined epidermis exists.[1] Lacaze-Duthiers (41) published an anatomical figure of young *Mytilus edulis* comparable to the prodissoconch stage and he notes the striking difference between the shell of that age and the adult. Lovén also published an anatomical figure of developing Mytilus which compares favorably in its shell form with Pl. XXIX, fig. 9.

An older specimen of *Mytilus edulis*, Pl. XXIX, fig. 10, shows no important differences from the younger specimen, fig. 9. The prodissoconch valves on account of the increased arcuateness of the umbos are not seen in side view as well as in the earlier stage, a

[1]Prismatic structure is described in the inner layers of Dreissena, but this genus has not been studied.

necessary feature of developing bivalves. Instead of being rounded in appearance as in fig. 9, the prodissoconch valves appear flattened from perspective. The prodissoconch of fig. 10 differs from that of the earlier stage in being chalk-white, the yellowish-brown organic appearance of the earlier condition having disappeared from the wearing away of the epidermis. The same is true of older specimens as long as the prodissoconch remains intact, and it may often be found in specimens up to 4–5 mm. in length. It then appears as a little white cap at the umbo of either valve. The nepionic stage of fig. 10 is similar to that of fig. 9, except that the lines of growth anteriorly are more crowded inward toward the umbo, in this feature making a nearer approach to the condition characteristic of the adult. Verrill notes collecting abundant young specimens of *Mytilus edulis* on the 12th of April, and I have found them in July, September and December, so that this species evidently has wide limits in its breeding season.

Modiola hamatus, Verrill. This species occurs on our coast from Vineyard Sound to Mexico. A number of young and adult specimens were collected at Martha's Vineyard and Long Island Sound, also specimens were obtained from a mass of *Perna ephippium* collected at Cuba. The young Modiola, has a well defined prodissoconch, *p*, Pl. XXIX, fig. 11, which is yellowish-brown and with umbos directed anteriorly as in Mytilus. The prodissoconch of Modiola appears flatter, less rounded than the prodissoconch of Mytilus, Pl. XXIX, fig. 9; but this is due in part at least to perspective as noted in the older specimen of Mytilus, Pl. XXIX, fig. 10. The hinge line of Modiola is produced posteriorly in a curving line and anteriorly the lines of growth approach the umbos in a sweeping curve, fig. 11. The form of this stage is not widely separated from that found in some species of the genus, but it more nearly approaches the form of the Modiomorphas, palæozoic allies of the Modiolas. An older specimen of *Modiola hamatus*, Pl. XXX, fig. 1, shows the introduction of the plications which are characteristic of the species. The plications originate suddenly, marking a distinct stage by their introduction.

Crenella decussata, Montagu. Young specimens of this species, loaned me by the Smithsonian Institution, show distinct prodissoconchs, *p*, as shown in Pl. XXX, fig. 3, an umbonal view of a specimen. The prodissoconchs have rather highly developed umbos which are directed anteriorly and show fine concentric lines of growth. The succeeding dissoconch in its initial stages of growth is already marked by radiating plications as well as concentric lines of growth which are coarser than those of the prodissoconch.

The Mytilidæ are classed with the Aviculidæ, as heteromyarians, the connection being based on the condition of unequal adductor muscles. This basis of classification, as previously considered (Introduction), is not deemed one of high, systematic importance and is insufficient to connect otherwise differing groups. The striking differences in the prodissoconch and nepionic stages of the Mytilidæ and Aviculidæ are sufficient I think to separate these groups, and the Mytilidæ should be put in a group distinct from the Aviculidæ and their allies, which I have shown are all bound together by important features as one group.

Argina (Arca) pexata, Verrill. An extremely small specimen, Pl. XXX, fig. 2, was found in a drain-pipe trap at Buzzards Bay. The specimen was dead, but the shell was perfectly preserved. The prodissoconch is ovally rounded, very sharply defined; and has well developed umbos which are nearly central. The prodissoconch shows delicate concentric lines

of growth, and is very yellow compared with the succeeding dissoconch growth which is pure lime white, thus indicating a somewhat more marked conchyolin basis of the prodissoconch. The succeeding dissoconch has the typical hinge line characteristic of the Arcas. Its first stages of growth are smooth and marked by nearly concentric lines of growth; but with no plications; well defined plications exist, however, in the later growth. Taking the shell as a whole, the height (measuring from the free border of valves to the hinge line) is much greater posteriorly than anteriorly. In the middle of the ventral portion a distinct depression exists on the border of the valves and also in the preceding lines of growth. The early dissoconch before the introduction of plications differs much in appearance from the adult and bears a strong resemblance to fossil members of the Arcidæ. Especially does it resemble species of Macrodon from the Devonian as figured by Hall. The teeth on the distal limits of the hinge line of young Argina are oblique like those of Macrodon, and between these oblique teeth are the perpendicular Area-like teeth; but at an earlier stage of growth the perpendicular teeth were apparently wanting, and then the teeth of young Argina would have been closely comparable to those of Macrodon. *Arca ectomata*, Dall, from abyssal depths has all the teeth oblique like those on the distal limits of the hinge line in young Argina and like those of the early and later species of Macrodon.

The stage represented by the whole shell of Pl. xxx, fig. 2, differs in form from the earlier Macrodon stage and also from the adult, and is comparable to Arca, the type-genus of the family. Transitional series of specimens of *Argina pexata* older than Pl. xxx, fig. 2, show in constantly increasing degree the oblong-ovate form and shaggy epidermis characteristic of the adult. In the ontogeny of Argina, therefore, we find that there are four distinct stages which represent the ancestral forms from which the genus was evolved: (1) the prodissoconch representing a primitive ancestral radical, at present unknown; (2) the Macrodon stage, comparable to palæozoic forms of the family; (3) the Arca stage, comparable to the type genus of the family and, finally (4), the Argina stage in which the features of the genus and species are introduced and fixed. A prodissoconch and nepionic stage similar to that described in *Argina pexata* has been found in a young specimen of *Arca barbata*, L., kindly given me by Professor Verrill, and in some young Arcas of an undetermined species from Japan. The nepionic stage of *Parallelopipedum tortuosum*, Lam., is also similar to the same stage of Argina, the tortuous character of the adult shell not having been acquired at this early period of growth.

It is an important fact that members of the Arcidæ have a prodissoconch, because as one of the oldest living groups of Pelecypods it shows the widespread existence in time as well as genera of a distinctly marked early embryonic shell. Species of so many and such widely separated families possessing a prodissoconch in the young is strongest proof that it is characteristic of the whole class of Pelecypods. We also see that the nepionic stages in members of this family can be made use of in tracing genetic relations, as in the Avicnlidæ and their allies.

The Unionidæ are naturally turned to in studies of this nature as they are characterized by a peculiar early stage called the glochidium. Although the glochidium is known by itself, I do not think the relation of this early shell to the adult has been previously studied. Through the kind intervention of Dr. Charles E. Beecher, I recently received some ma-

terial which was collected by that gentleman, from Mr. William B. Marshall of the New York State Museum. The specimens embrace glochidial stages from the gill cavities of the parent and adults with perfectly preserved umbos, so that the early embryonic shell is still intact, and thus affords the opportunity of a comparison with later stages.

Unio cariosus, Say. The glochidium stage of this species, fig. 44, p. 367, is sub-quadrate with a straight hinge line and rounded angles on the ventral border. The shell has a double line around its border, the inner line representing the limits of an earlier stage of growth. A similar double line exists in the glochidium of all Unionidæ observed, or which I have seen figured, and Dr. Lea makes the same observation. On the middle of the ventral border of the valves is a very abbreviated spur which is not, however, spinous as in Anodon. The single adductor muscle is situated near the hinge line and a little nearer the anterior than the posterior border of the shell.[1] The shell is granulated on its surface and presents no traces of prismatic structure, the same feature being found in the glochidium of all the Unionidæ observed. The glochidial shell of *U. cariosus* and other species of the genus is whitish and much smaller than is the glochidium in Margaritana and Anodon. The glochidium of *Unio nasutus*, Say, is similar to *U. cariosus* as described. Dr. Lea figures the glochidium from the gills of the parent in twenty-five species of Unio. Twenty are similar to *U. cariosus* in form with some little variation in contour. Of the five remaining species three are sub-triangular resembling some species of Anodon; but two have the ventral angles produced instead of rounded and each angle of either valve bears a small spur.

Unio pressus, Lea. A specimen 47 mm. in length has the umbos well preserved and still bears the early glochidial shell. This embryonic shell is sub-triangular and has the same form as is figured by Lea in a specimen from the gill chambers of the parent of this species. It is immediately succeeded by the nepionic stage of the dissoconch which has the prismatic structure and concentrically rugose growth which is characteristic of the young shell in Unionidæ and is often figured at the umbos of well preserved specimens (see Lea and other authors). The glochidial shell in its relation to the dissoconch therefore fills the requirements of the prodissoconch and may be compared with that stage as described in many genera in this paper. The Unios above described were collected in Albany County, New York, by C. E. Beecher.

In *Margaritana undulata*, Lea, the glochidium, fig. 45, p. 367, is sub-triangular, but the anterior end of the embryo is considerably the larger. The hinge line is straight and the valves at this area are raised in little humps indicating abbreviated umbos, not shown in the figure. The angle at the ventral border of the shell is quite sharp; it is posterior to a median line drawn perpendicularly through the shell and bears a denticulate spur on either valve similarly to Anodon. In other features the shell is like the glochidial stage of Unio. A young specimen of *M. undulata* 13 mm. long, fig. 48, has the umbos well preserved and they retain the glochidium or prodissoconch intact. The hinge line of the prodissoconch is parallel to the hinge line of the succeeding dissoconch growth and the larger end of the embryonic shell is directed toward the anterior end of the shell. The prodissoconch has the granulated surface characteristic of the glochidia of this and other

[1] The glochidial shell of all or nearly all Unionidæ is a little larger on one side than on the other of a line drawn perpendicularly through the hinge line and middle of the ventral border of the valves.

species of the family; but the dissoconch has an external layer of prismatic tissue. Camera drawings of this specimen show that the prodissoconch is of the same size and form as are the glochidia when removed from the gills of the parent as shown in the figures, and the same observation holds in regard to the size and form of glochidia and completed prodissoconchs in every species in which I was able to make the comparison. The glochidial shell of *Margaritana marginata*, Lea, is similar to that of *M. undulata*. Lea figures the glochidium of five other species of this genus. Of these, three are similar to the glochidium of *M. undulata;* but two are less triangular and more rounded on the ventral border. A specimen of *Margaritana margaratifera*, which is 55 mm. long has the umbos well preserved and they bear at the tip the embryonic shell. As in the previous species the prodissoconch of this species is sharply marked off from the succeeding dissoconch, and in a camera drawing it coincides in form and size, with the glochidium from the gills of the parent. Specimens of *Margaritana deltoidea*, 19 mm. long, have the prodissoconch well preserved and it presents the same features in relation to the succeeding dissoconch as in the above-mentioned genera. The specimens of *Margaritana undulata* studied were collected in Albany County, New York, and those of *M. margaritana* and *M. deltoidea* at Ann Arbor, Michigan, by C. E. Beecher.

FIG. 44.

FIG. 45.

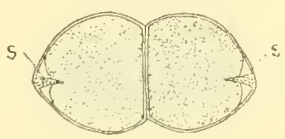


FIG. 46.

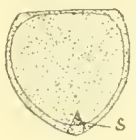


FIG. 47.

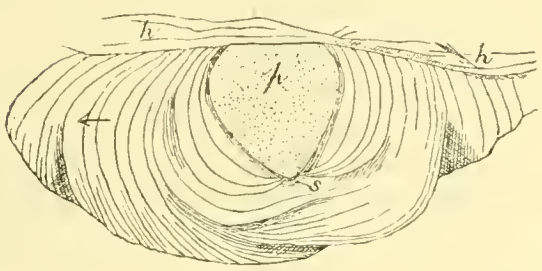


FIG. 48.

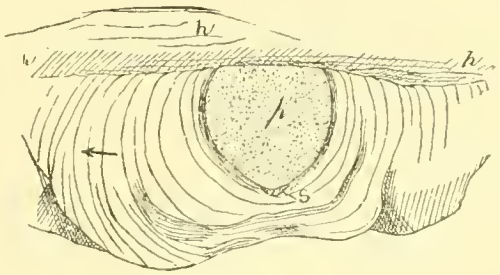


FIG. 49.

FIG. 44.—*Unio cariosus*, glochidium from the gills of the parent.

FIG. 45.—*Margaritana undulata*, glochidium from the gills of the parent.

FIG. 46.—*Anodon cygnea*, glochidium from the gills of the parent.

FIG. 47.—*Anodon fluviatilis*, glochidium from the gills of the parent.

FIG. 48.—*Margaritana undulata*, umbonal tip of a young shell, showing the prodissoconch, *p*, still in place and the nepionic stages of the succeeding dissoconch.

FIG. 49.—*Anodon fluviatilis*, umbonal tip of a young shell showing the prodissoconch, *p*, still in place and the nepionic stages of the succeeding dissoconch.

All the figures (except fig. 46) are of left valves. The arrows are directed toward the anterior end of the shell; *s*, glochidial spurs; *h*, hinge. All the figures × 50 diam. (Drawn by the author.)

In Anodon the glochidium is better known than the same stage of other genera of this family, as it has been more often studied by embryologists. Schmidt studied it during the period of parasitic life which it leads on fishes, and good figures of this stage are given by that author. The glochidium of *Anodon fluviatilis*, Lea, fig. 47, is sub-triangular in

outline but is less acutely angular on the ventral border than is this stage of Margaritana. The hinge line is straight; the anterior end of the shell is somewhat the larger and spinous spurs exist at the ventral angle of either valve, Pl. XXIII, figs. 7–8. A double line surrounds the limits of each valve and the surface of the valves is granulated, the same characters existing in the glochidium of Unio and Margaritana. The inner line is distinct from the edge of the shell and represents an earlier stage of growth. In *A. cygnea*, fig. 46, p. 367, the double line represents the thickness of the edges of the shell, and the inner line representing an earlier stage as in fig. 47, is not seen in this view. The glochidium of Anodon differs from that of the other genera in the species observed in being of a brown color. A glochidium similar to that described in *Anodon fluviatilis* I have observed in glochidia from the gills of the parent of three other species, namely, *A. undulata*, *A. cylindracea* and *A. cygnea*, fig. 46. There is great constancy in size and appearance of the glochidia in the different species of Anodon observed, the uniformity being greater than in the other genera of the family.

A well preserved specimen of *Anodon fluviatilis* 25 mm. in length, fig. 49, p. 367, has the embryonic shell or prodissoconch still in place. The prodissoconch in a camera drawing of this specimen coincides in size and form with the glochidia from the gills of the parent, no increased growth being observed. The larger end of the embryonic shell is directed anteriorly and the hinge line is parallel to the hinge line of the succeeding dissoconch. The dissoconch has the rugose fluting characteristic of the young (frequently figured at the umbos in well preserved specimens by Lea and others) and presents well defined prismatic structure. The glochidia of *Anodon fluviatilis* described and the older specimen of the same species as also the glochidia of *A. undulata* and *A. cylindracea* were collected in Albany County, New York, by C. E. Beecher. The glochidia of *A. cygnea* are from Belfast, Ireland, and were loaned to me by the Smithsonian Institution.

The fact that the larger end of the prodissoconch is directed anteriorly in all the species of Margaritana and Anodon in which it was still found in place at the umbos of the valves, is convincing proof of the correctness of Schmidt's observation that the larger end of the embryo of Anodon is the anterior end. It is a remarkable fact that the completed prodissoconch in the various species observed has the same form and size as does the glochidial stage of the same species when removed from the gills of the parent. We know from the observations of Balfour and Schmidt that after quitting the gills of the parent the embryos of Anodon (and probably, from analogy, other genera of the family as well) lead a parasitic existence in the gills, fins, etc., of fishes. During this period of parasitism considerable anatomical changes take place, yet these changes are not accompanied by any noticeable modification or increase in size of the embryonic shell.

It is seen that the glochidial shells of the genera of the Unionidæ described are sub-triangular or subquadrate; but always with a straight hinge line. But a single adductor muscle exists and other anatomical features are in a very early condition of development. This stage is directly the equivalent of what I have described as the phylembryonic stage (p. 291) of development in Pelecypods and it may be compared to the embryos of Modiola, Cardium and Montacuta, Pl. XXIII, figs. 9–11, also of Ostrea, fig. 25, p. 300, and Pl. XXIV, figs. 13–15. The anatomy of the glochidium from the gills of parents is less advanced than is the same (phylembryonic) stage in other genera, as shown in the figures cited; but this is explained as a peculiarity due to the specialized development of this type.

It is a striking fact that the embryonic shell of the completed prodissoconch period of the Unionidæ has not changed in form or size from the condition it had when ready to leave the gills of the parents. This fact and the correlated fact that umbos have not developed, although they exist in the prodissoconch of the twenty-six other genera described in this paper, are proof of the extreme reduction of the embryonic shell. The completed prodissoconch of the Unionidæ, therefore, has not progressed in the features of the shell beyond the phylembryonic stage, which is found only in early embryonic stages of other genera. This high reduction is probably to be explained by the condition of parasitism which exists at this period in the development of the embryo. While the prodissoconch of the Unionidæ is in all cases granulated on the surface and shows no prismatic tissue, the succeeding dissoconch is characteristically prismatic. This condition is comparable to what I have described in the Aviculidæ and their allies, but differs from what I have found in other genera.

What the affinities of the Unionidæ are is a puzzle, for they are not clearly related to any other family. The peculiar form, the spurs and absence of umbos in the prodissoconch are special features, apparently due to the peculiar environment of the developing embryo. Although it cannot be supposed to fully represent in the ontogeny of the individual any ancient ancestral form, yet certain data can be gathered from this early shell. As the prodissoconch of the Unionidæ has no prismatic tissue, it is doubtless the representative of an early ancestor which was without that structure (the same comparison that is made in the prodissoconch of the Aviculidæ). The radical ancestor, of which this prodissoconch is the inherited representative, probably had umbos directed posteriorly, for though the prodissoconch of the Unionidæ has no umbos, the more rapid growth on the anterior border would have pushed umbos posteriorly had they existed. That this ancestor was dimyarian might be conjectured; but is fully implied by the fact that the completed prodissoconch has two adductor muscles, for Balfour's and Schmidt's figures of a mature glochidium of Anodon from a fish have two adductors. The nepionic stages of the Unionidæ, though peculiar, do not so far as I am aware indicate kinship with early predecessors of the group.

Sphærium securis, Adams. This species was collected in a culvert at Medford, Mass., in November. The adults were crowded with large embryos, and as many as fourteen were taken from the gills and mantle cavity of the parent. The embryos, Pl. xxx, fig. 4, show no traces of a velum as far as discerned, but have a well-developed foot and crawl actively when removed from the parent. The foot has a prominent otocyst as figured in Cyclas by Ziegler and other investigators; but no byssal gland was observed as described in that genus. Two adductor muscles, palps and filamentous gills exist. The mantle border is produced posteriorly in a single siphon, fig. 4, but is free throughout the rest of its exposed margin. In older specimens and the adult, two siphons exist, an excurrent and an incurrent. This was not seen in the young of the age under consideration, but as the point was not in mind when studying the specimens, it is possible that two might be found. If not, it is an interesting character, for the adult of Pisidium has but one and the existence of one in young Sphærium would appear to be of genetic significance. The shell of Sphærium, Pl. xxx, fig. 4, represents an incompleted prodissoconch stage. In Pl. xxx, fig. 5, also from the gills of an adult, a completed prodisso-

conch, *p*, exists and is succeeded by considerable dissoconch growth. The prodissoconch is globose and almost circular, slight umbos being developed. When young, fig. 4, it is very translucent of a light horn color, but in older specimens, fig. 5, the shell is thickened by shell deposition, and it is darker and more opaque. The prodissoconch in Sphærium is of gigantic size compared with the prodissoconch found in other Pelecypods described and figured in this paper. Pl. xxx, fig. 5*a*, is a young specimen magnified only ten times in order to show the large size of this early shell. By definition, the prodissoconch in Pelecypods is the shell of the completed embryonic period, and it is natural that in Sphærium we should have a large prodissoconch because of the relative great size of the embryo in that genus.

Besides in *Sphærium securis*, a similar strongly marked prodissoconch has been observed in *S. partumeium*, Say, *S. rhomboideum*, Adams, and *S. transversum*. The specimens of these species observed are in the choice Beecher collection of fresh water shells, in the New York State Museum.

Echinochama (Chama) arcinella, L. In a specimen sent me by Dr. Beecher, a prodissoconch was found intact. It is ovally rounded with umbos directed anteriorly. The nepionic stage is pink in color, is ovately drawn out, and truncated posteriorly. Concentric ridges mark the nepionic period and as pointed out by Fischer, this early stage resembles a Venerupis in form. The shell of the nepionic stage is equivalvular as observed in several specimens in the collections of the Boston Society of Natural History. As soon, however, as the right valve becomes attached to a foreign body (which occurs when the shell is about 3 mm. in length), both valves immediately change their form and assume the irregular growth characteristic of the Chamas, and soon the spines and pit-like depressions characteristic of the species are introduced. We find in this case a full substantiation of our views on the modifying effects of the conditions of fixation on shell form as fully discussed in section VIII, p. 322.

Petricola pholadiformis, Lam. At Nantucket in July, 1889, a large number of young specimens of this species were collected, varying from very small to 12 mm. in length. The largest individuals had the adult characters fully developed. The specimens were burrowing in shallow Mytilus beds which covered rocks between tide marks. In the youngest specimens found, Pl. xxx, fig. 6, also in some older individuals, a distinct prodissoconch, *p*, exists at the umbos. It is not widely different from the succeeding dissoconch in form, but is sub-ovately rounded and appears like a cap on account of its whiteness compared with the succeeding grayer dissoconch. The whiteness of the prodissoconch is noted in several genera in this section, and as described in Mytilus it is doubtless due to the wearing away of the organic epidermis of the valves and consequent exposure of the chalky-white lime basis. The early dissoconch of Petricola, Pl. xxx, fig. 6, is strikingly different from the adult. It is oblong, anteriorly roundly compressed and posteriorly slightly truncated. The lines of growth indicate an earlier more oval form. In this early stage the ligament, *l*, projects from the hinge line as in the later stage, Pl. xxx, fig. 7, and in the adult; but no plications of the shell exist until considerably later. The specimens, although taken from their burrows in the Mytilus bed, proved to be active crawlers having a highly developed foot, fig. 6. The siphons of this early stage fig. 4, are separate for the entire length produced beyond the limits of the shell. The

incurrent siphon as in later periods is the longer of the two and the two tubes are widely divergent as in the figure. The excurrent siphon is not retracted and extended periodically as described in Mya, Pl. xxx, fig. 13, and no tentacles surround the base of either siphon tube in Petricola. The distal tips of the tubes in Petricola, fig. 6, are fringed by by a few simple unbranched tentacles.

An older specimen of *Petricola pholadiformis* than that just considered is shown in Pl. xxx, fig. 7. The umbos are too arcuately incurved to show the prodissoconch if it were existent, and as a fact, it is not, being eroded away before this period is reached. The younger portion as indicated by the lines of growth is oval and marked by coarse concentric lines. A distinct stage is indicated in the oval portion of this specimen and similar stages are common, but variable in individuals. The umbos are progressively pushed anteriorly during the younger growth. Rugose plications originate suddenly, the earliest stages having none. From the period of the introduction of plications, the shell rapidly assumes features characteristic of the adult, differing principally in not being so elongate, differing also of course in that the rugose plications of the adult are produced nearly to what then becomes the umbo of the shell. The siphon tubes of Petricola of the age of fig. 7, are long and are capable of being extended to a length considerably greater than the total length of the shell. They are separate throughout their length beyond the shell borders as in the younger specimen, fig. 6. In the adult, on the contrary, Verrill says they are united for about a quarter of their length. In specimens of the age of fig. 7, the branchial siphon, Pl. xxx, fig. 8, is surrounded at its tip by tentacles which branch laterally, intermediate with which are some simple unbranched tentacles. The dorsal excurrent siphon of the same and of similar specimens on the contrary has no branching tentacles, all being simple as in fig. 6. This condition of the orifices is similar to that of the adult described by Verrill, excepting that he says some branching tentacles exist at the orifice of the excurrent siphon though fewer than at the orifice of the branchial siphon.

Venus mercenaria, L. I secured a number of young shells of this species in the drain-pipe traps at Buzzards Bay. The youngest specimen, Pl. xxx, fig. 9, has a sharply defined prodissoconch which is yellowish-white, covered with a delicate epidermis and bears fine concentric lines of growth. It is separated from the succeeding dissoconch growth by the changes then introduced in the marking of the shell, angles of curvature and color, which though covered with a thin epidermis is nearly chalk-white. The first stages of the dissoconch are marked by the series of concentric ridges and furrows characteristic of young shells of this species, but which are wanting in the adult. This feature is shown at the umbos of Dr. Gould's figure of the species. Ridges and furrows like those found in young *Venus mercenaria* are characteristic of the adult in some species of the genus, as *Venus rugosa*, Chem., of the West Indies. The same feature is shown in a high degree in the closely allied genus Chione, and its occurrence in young *Venus mercenaria* is evidently of genetic significance. In its earliest growth, Pl. xxx, fig. 9, the dissoconch shows only faint traces of a lunule (which was unfortunately overlooked when the figure was drawn) but it is a marked feature in the older specimen, Pl. xxx, fig. 10, and is characteristic of the adult.

Tottenia gemma, Perkins. A few young specimens were collected in August at Buz-

zards Bay. The prodissoconch is oval, rounded and not sharply defined from the succeeding dissoconch, as both have nearly the same shape and the same peculiar violet color. The prodissoconch is marked by a fine pitted structure which partially obscures the lines of growth. The dissoconch bears closely crowded lines of growth and is violet or amethyst color over its whole surface. In the adult, on the other hand, the shell is mostly white or rosy, the amethyst color being limited to the umbonal and posterior portion of the shell. Gould says this species is commonly taken for the fry of *Venus mercenaria* on account of the color of the tip (young). This is an unnecessary mistake as the lunule, elevated ridges and white color of young individuals of that species (Pl. xxx, figs. 9–10) are wanting both in the young and adult of Tottenia.

Scrobicularia tenuis, Pl. xxx, fig. 11, illustrates a specimen from the collections of the Smithsonian Institution. It has a distinct prodissoconch which is not, however, as sharply defined as in many genera because the succeeding dissoconch is so like it in form that no marked contrast is produced by the introduction of that later stage. The prodissoconch shows concentric lines of growth and its limits are defined by a varix of growth indicating the close of the stage.

Saxicava arctica, Desh. Young specimens were collected on the roots of Laminaria at Cohasset and Chelsea Beach in September, 1889. A very sharply defined prodissoconch exists at the umbos, fig. 50. It is ovate with umbos directed anteriorly and shows fine concentric lines of growth. The succeeding dissoconch is oblong, covered with a delicate epidermis, as is the prodissoconch and bears comparatively coarse strongly defined lines of growth. The ligament is external and forms a prominent feature of this early stage as well as in the adult. Two ridges which extend posteriorly from the limits of the prodissoconch valves are ornamented with spines. The spines vary in size and number, but persist in specimens up to four or five millimeters in length after which they were not observed. Their existence is noted in the young of Saxicava in Binney's Gould.

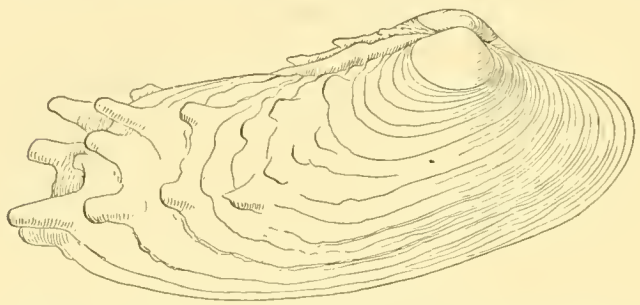


Fig. 50.—Young *Saxicava arctica*, showing oval rounded prodissoconch and succeeding spinous dissoconch. The ligament is external and prominent. × 38 diam. (Drawn by J. H. Emerton.)

Mya arenaria, L. A number of young living individuals of this species were found actively crawling on the glass slides in the drain-pipe traps at Buzzards Bay during August, 1888; the specimens varied from 0.6 mm. to 5 mm. in length. At Chelsea Beach, Mass., in September, 1889, many clams were also collected, from very young to those having the adult characteristics fully developed. The specimens varied from 1.5 mm. in length upwards, and instead of being free crawling, as were those collected at Buzzards Bay, they were for the most part burrowing in a bed of dead eel grass where the roots and mud formed a comparatively solid mass. The burial was superficial and so abundant were the little clams that a handful of the material might contain fifty specimens more or less.

In very young Mya, Pl. xxx, fig. 13, a remarkable condition of the siphon tubes exists.

The tubes are divided from the base beyond the shell margins and are not coalesced at any point visible when fully extended. The relation between this condition and that found in the adult is of much interest and was fully illustrated in the specimens which I studied alive. The excurrent tube, Pl. xxx, fig. 13, is composed of most delicate transparent tissue. It is prolonged in a proboscis-like fashion and is frequently extended and retracted with a jerky irregular motion. Water is expelled intermittently, and between the expulsions the siphon tube is somewhat retracted. The tube has a small contracted orifice and a tentacle was noticed at its base. More tentacles at this region doubtless existed, for many are found in the next stage, but they were not observed. The incurrent branchial siphon tube, fig. 13, is much shorter than the excurrent tube. It has thicker walls, bears a circlet of simple tentacles at its orifice and does not take part in the frequent extensions and retractions characteristic of the excurrent tube. The siphon of an older specimen measuring about 7 mm. in length is represented in Pl. xxx, fig. 14. Short termini of the excurrent and incurrent siphon tubes similar to those of fig. 13 exist at the tip; but between these and the shell, a massive coalesced growth of the tubes has developed by interstitial growth of the extended mantle border. Thus the portions of the siphons which are found in fig. 13 are now pushed out to the terminus of what may be called the massive siphon. The massive siphon is pigmented in dots, especially near the terminus which approaches nearest to the light, and it is covered by a delicate epidermal layer as in the adult. Tentacles fringe the free, distal border of the massive tube around its entire circumference, and a line of black pigment closely underlies the tentacles. The excurrent terminus, as in fig. 13, is composed of delicate tissue, is extensible and has a small contracted orifice which is plain, bearing no tentacles. Under higher magnification small dots regularly placed were observed on the walls of the excurrent terminus. The incurrent siphon terminus, as in fig. 13, is shorter than the excurrent. It is composed of thicker tissue and is constantly extended, not intermittently extended and retracted as is the excurrent terminus. Tentacles surround the orifice of the incurrent siphon and between the tentacles is black pigment bordered by orange; the tentacles also are themselves slightly pigmented. The pedal orifice of the mantle border in specimens of this age bears short papillose tentacles.

The development of the siphon from the condition just described, Pl. xxx, fig. 14, to the adult condition is merely a series of mechanical changes. The massive siphon elongates proportionately until, as Verrill says, in the adult it can be extended to the length of a foot or more. The termini of the tubes described in the young exist in the adult, but are so reduced in proportion to the entire siphon that they are hardly noticeable. The incurrent terminus is so short that it appears, as I have seen it described, that two rows of tentacles exist at this opening, whereas the fact is that one row surrounds the tip of the massive siphon and the other the free border of the incurrent siphon terminus as in fig. 14. The true condition of the parts in the adult is clearly figured by Morse, in his "First Book of Zoölogy."

A condition of the siphons, similar to that of Pl. xxx, fig. 14, exists in adult *Mya truncata*, as figured by Forbes and Hanley, and a condition similar to that of the earlier stage of *Mya arenaria*, Pl. xxx, fig. 13, is found in the adults of several genera, some closely allied to Mya and some not. Most important to us is the fact that this early condition of

the siphon exactly corresponds to what is found in the adult of Corbula (see Fischer, fig. 855). Corbula presents in the adult many features found in the early development of Mya and as it is the most ancient member of the Myidæ, being known from the Trias up, these facts are features of genetic importance in Mya. The great development of the siphon in *Mya arenaria* is most distinctly a correlation of structure induced by its habit of deep burial, and in the development of the individual we find that with increasing age as the individual burrows deeper the siphon elongates.

Professor Ryder (63), in a paper recently published, announces the discovery of a byssated condition in young *Mya arenaria*. Specimens studied at Buzzards Bay did not show this feature, although kept alive for several days; the clams from Chelsea Beach, however, did show it. I had them in glass dishes and many became attached to the sides and bottom. The byssus is produced from the ventral border of the foot at about the position of its point of extrusion from the shell in Pl. XXX, fig. 13. The animal attached itself as observed by a few (1–4) colorless threads of great delicacy. The threads were not expanded in disc-like distal termini as in the byssus of Pecten and Mytilus, but were glued to the glass for a considerable part of their length. Sharp angles in the line of the attached portion often existed, and separate threads often coalesced proximally. Byssal fixation occurred in specimens varying from 2.7 mm. to 9 mm. in length, and it was evidently a strong habit, for when detached, in a few minutes the fixation was again effected. A byssal cleft is characteristic of Corbula and Sphenia, near allies of Mya, according to authors, and Forbes and Hanley state that a byssal cleft exists in the foot of *Mya truncata*. In a very young specimen of *Mya arenaria* studied alive, the gills were filamentous, ciliated and expanded at their tips as shown in the gills of young Ostrea, Pl. XXIV, fig. 3. I did not determine certainly whether cross-bars united the tips or not.

A young specimen of *Mya arenaria*, Pl. XXX, fig. 12, shows the prodissoconch, *p*, clearly. The prodissoconch is rounded in outline, with umbos directed anteriorly. It is glistening and translucent, covered by a delicate epidermis and marked by fine concentric lines of growth. The prodissoconch may be retained in well preserved specimens, much older than fig. 12, even in those which are several millimetres in length; but commonly it is lost early from erosion. The prodissoconch is not so sharply marked off from the succeeding growth in Mya as in many genera, because the dissoconch growth has no striking features which originate with its introduction. It is, however, perfectly clear when preserved.

Professor Ryder (63) in his paper on *Mya arenaria*, published January, 1889, says that he did not find an embryonic shell in young clams such as is characteristic of young oysters. Since that time I have sent him specimens showing the embryonic or larval shell (prodissoconch) of Mya, and he acknowledges their existence in a letter, saying: "The specimens which you have been good enough to send show the larval shell very distinctly indeed, much more plainly than my own materials, in fact."

The dissoconch growth of *Mya arenaria* is covered with a delicate epidermis and is much whiter than the prodissoconch. I did not find any trace of prismatic cellular tissue in the young shell of Mya. The early dissoconch growth, Pl. XXX, fig. 12, is rounded in outline anteriorly, but truncated posteriorly and marked by fine concentric lines of growth. An older specimen of a clam is seen in Pl. XXX, fig. 13. The prodissoconch

of this later stage, on account of the arcuateness of the umbos, is not seen so clearly in side view as in the younger stage. The shell differs much from the adult in form, being less rounded anteriorly and less pointed posteriorly, also the valves gape less proportionately than in the adult. An angular ridge runs from the umbos posteriorly to the ventral border of the valves, emphasizing a flattened area above it. The features described are found in older young specimens, but gradually fade out and in successive growth give place to the characteristics of the adult.

The young shell of *Mya arenaria* bears a marked resemblance to some species of Corbula (leaving out of consideration the inequality of valves in many species of that genus); especially does it resemble *C. contracta*, Say, of our coast. The anatomy of young Mya also bears a close resemblance to the adult of Corbula (see Fischer's fig. 855) in possessing a similar siphon, Pl. XXX, fig. 13, papillose tentacles on the mantle border at the point of extrusion of the foot and a byssated foot. As Corbula is the oldest known genus of the Myidæ, being found from the Triassic upwards, and as it presents similar features to those found in the young of Mya, it is probably in the line of ancestry of the Myas and is a near representative of the form from which they have descended.[1]

XV. On the Genetic Relations of the Prodissoconch.[2]

In the development of Pelecypoda at an early embryonic stage, which I have described as the phylembryo stage, the two valves of the shell are sub-circular or saucer-shaped; but flattened into a straight line at the hinge area where they are joined by a ligament. This stage is characteristic of many developing Pelecypods (Pl. XXIII, figs. 7–11; Pl. XXIV, figs. 13–16 and fig. 25, p. 300)[3] and apparently represents a primitive ancestral condition common to the whole class. Embryology shows that the Pelecypod shell originates from a single shell gland and that the two valves doubtless arose from the splitting on the median line of a primitive univalvular ancestral form. If that ancient univalvular radical had a saddle-shaped shell as in young Dentalium, Pl. XXIII, fig. 13, or a cup-shaped shell as exists in very early stages of cephalous mollusca,[4] the first result of the introduction of a median hinge would be to straighten the shell on the hinge line. This is a simple problem in mechanics; for, if one tries to break by flexion a piece of metal which is saddle-shaped or cup-shaped, the metal will tend to form a straight

[1] Since this paper was in press, a prodissoconch has been discovered in a number of genera not considered in the foregoing pages. An ovally rounded prodissoconch has been found in *Nucula proxima* and in Tellina. In both genera the umbos of the prodissoconch are directed posteriorly as in the adults. A prodissoconch has also been discovered in Chione, Cardita, Cardium, Mactra and a number of undetermined genera belonging to other families of Pelecypods. In these latter the umbos of the prodissoconchs are directed anteriorly, and the succeeding dissoconch is destitute of prismatic cellular tissue.

[2] This section and the next one, XVI, have been considerably altered and added to since this paper was offered as a thesis at Harvard University on May 1, 1889. The additions are not indicated excepting by this note.

[3] It is also described in Teredo by Hatschek. Exceptions to the rule occur as in Pisidium, where according to Lankester (43) the early embryonic valves are triangular. I think such cases may be considered exceptions in which the straight hinge period is skipped by acceleration of development.

[4] The shell of Gasteropods, as I have observed in studies of Sycotopus, is cup-shaped before it acquires the spiral form of the completed protoconch, and a similar condition is shown in Lankester's (43) figures of Aplysia. The shell of Pteropods and Cephalopods is also at first cup-shaped as is obvious in studying the changes that must take place in the building up of the completed protoconch, Pl. XXIII, figs. 15–18.

line on the axis of flexion. A directly parallel case is the condition existent in bivalvular crustaceans. These originate by the introduction of a hinge in the median line of the carapace of a normal crustacean. The ancient Ostracoda,—Leperditia, Aristozoe, etc., have a straight hinge line and sub circular valves which are united on the hinge line by a ligament. Thus, the resulting form of the bivalvular shell in these two entirely distinct classes is strikingly similar.

The next stage in the development of the Pelecypod shell is the loss of the early straight hinge line which is superseded by a curving of the hinge line and a centralization of connecting tissue and teeth of the two valves in the median line of the hinge.[1] The necessary form of the valves of an equilateral bivalve, freely crawling on the ventral border, is curved in section. Therefore, more or less arcuate umbos would develop during successive growth. This condition of growth would bring the shell to the form of the completed prodissoconch stage which is the representative of ancestral type radicals in the ontogeny of the individual. A close parallel of this later stage of shell growth is again to be found in bivalvular crustaceans. Some genera, as Estheria, have a curved hinge line, more or less arcuate umbos, and bear a close resemblance to Pelecypods. In this consideration of the mechanical origin of the Pelecypod shell, especial attention should be called to a highly interesting and important paper by Dr. Dall,[2] in which he demonstrates in a most striking manner the mechanical relations of the ligament and cartilage to the hinge in Pelecypods, and the progressive, mechanical development of systems of hinge teeth in this class.

The form of the shell up to the close of the prodissoconch stage seems to be the natural outcome of the bivalvular condition. I think the muscles which close the valves may be demonstrated to be the necessary consequent of the mechanical conditions of a bivalve shell. The anterior adductor muscle in Pelecypods is reduced and finally disappears when it comes into such position that its functional activity is lost, *e. g.*, Ostrea, Pecten, Mulleria, etc. (section v). The posterior adductor also may disappear through disuse. In Aspergillum, where the two valves have united so as to form a simple tube,[3] and therefore, of course, the action of the adductor muscles is lost, the posterior adductor has disappeared and the anterior is reduced to a few disconnected shreds (Fischer). In the phylembryo stage of Pelecypods, fig. 25, p. 300, Pl. XXIII, figs. 7–11, the valves are closed by a single adductor muscle, the simplest condition mechanically possible to effect the desired end. This adductor does not seem to be homologous with any muscle in other classes of molluscs, and it probably developed as a necessary consequence of the

[1] A straight hinge line is characteristic of many Pelecypods and it is not easy to perceive what causes led to the adoption of a curved one in the primitive radicals of the class. That it was adopted, however, is predicated by the form of the completed prodissoconch as described in these pages. See Plates XXIV–XXX. The prodissoconch of the Unionidæ has a straight hinge line, the reasons for which are discussed on p. 368.

[2] On the hinge of Pelecypods and its development, with an attempt toward a better subdivision of the group. By Wm. H Dall, Am. Journ. Sci., Vol. XXXVIII, pp. 445–462. Published since this paper was in press.

[3] The tube of this and similar genera is commonly spoken of as if it were something separate and distinct from the shell, whereas it is a modified condition of the shell and should be so considered. In the young of Aspergillum every step can be traced between the typical bivalvular stage and the period when the two valves merge into one another by concrescence and form the truly univalvular condition characteristic of the genus. This concrescence of the apposed borders of the two valves in Aspergillum is paralleled by the concrescence of the two sides of the embryonic saddle-shaped shell of Dentalium, Pl. XXIII, fig. 14, which unite to form the tubular shell of the adult, as described by Lacaze-Duthiers (42).

conditions of the case.[1] In support of this view, the bivalvular crustaceans may again be cited as they have an analogous adductor muscle, developed, of course, on an entirely different line of descent, but under closely similar mechanical conditions. In the completed prodissoconch of all Pelecypods there are two adductor muscles, Pl. XXIV, figs. 1–2, Pl. XXX, fig. 4,[2] thus arriving at what may be called in this respect the *typical condition of the class.* During later life the anterior, the posterior, or both adductors, may be retained, reduced or lost, according as the persistence or changes in correlated features of anatomy retain in use or bring into disuse the muscles in question.

The preceding studies show the existence of an embryonic shell to which I have given the name of prodissoconch (p. 311) in many widely separated genera of Pelecypoda. We will now consider this early shell and see if any close connection can be traced between it and ancestral forms of which it is the representative in early stages of development.

Two classes of prodissoconchs and succeeding shell structure are described in the preceding pages. In the first division the prodissoconch has umbos directed posteriorly and is not prismatic, but is succeeded by a dissoconch having an external layer of prismatic cellular tissue which is more or less developed, but exists at least in the early nepionic stages of one valve. These features are characteristic of the Aviculidæ, Ostreadæ, Pectinidæ and Anomiadæ, as shown by representative genera. The second division is less well defined; but with one exception can be separated from the first. The prodissoconch of this second division has umbos which are directed more or less anteriorly. It has no prismatic cellular layer and is succeeded by a dissoconch which has no prismatic layer. Such features are characteristic of genera representing the families Mytilidæ, Arcidæ, Chamidæ, Petricolidæ, Cycladidæ, Veneridæ, Glycimeridæ, Scrobiculariidæ and Myidæ. The young of the Unionidæ as described (page 305) does not come under this second section but in some features approaches the first. Only a part of the families of Pelecypods are included under these two divisions. Whether other families will come under one or the other, or yet new divisions, must be proven by future investigations (see note, p. 375).

The first of the divisions above considered embraces a group of families (the Aviculidæ and allies) intimately bound together as I have attempted to show in this paper. It will probably prove to be a group of ordinal value and *I shall limit myself to this group in considering the derivation of the prodissoconch.* The prodissoconch of the second division has doubtless a different ancestral kinship or perhaps several lines of ancestral kinship as the case may be.

The features by which a possible connection may be traced to the radical ancestor from which the prodissoconch form is inherited includes features of shell structure and anatomy, for we know both in a measure from the results of the studies in this pa-

[1]The mantle of molluscs often has a highly developed muscular system, and it seems probable that the adductors of the Pelecypod arose from a modification of mantle muscles. A somewhat similar modification of these muscles is seen in the retractor muscles of the siphon, characteristic of many Pelecypods, as the clam, Pl. XXV, fig 9.

[2]Also figures by Lovén, Schmidt and other investigators of marine and fresh-water Pelecypoda The fact of the two adductors is also attested by the form of the prodissoconch in the genera figured on Plates XXVI–XXX inclusive.

per. These two lines of inquiry linked with the proper palæontological sequence are found to point directly to a form which fills the necessary requirements of such an ancestor. Data for the inquiry. *The shell.* In Avicula, Perna, Ostrea, Pecten, Anomia and allies a prodissoconch exists in which the structure is homogeneous and laminar, sub-nacreous, not prismatic, though succeeded by a dissoconch having well-defined prismatic structure. The umbos of the prodissoconchs are directed posteriorly, and the hinge line is curved. The only genus in which we know the prodissoconch before any dissoconch growth has taken place, so to enable us to determine features of the hinge line, at this stage is Ostrea. In *Ostrea edulis*, fig. 26, p. 312, the prodissoconch has teeth at right angles to the hinge line, and these teeth closely resemble the teeth of Nucula, when a shell of that genus is viewed from the umbonal region as in the figure cited. In *O. virginiana*, however, no teeth were observed. *The anatomy* as illustrated by the various genera yields points of great synthetic value. The prodissoconch has two adductor muscles as proven in Ostrea, Pl. XXIV, figs. 1–2, and inferred in the other genera from the form of the prodissoconch valves and the kinship to Ostrea (see studies of Perna, Avicula, Pecten and Anomia). In the prodissoconch stage of Ostrea the gills are simple unpaired filaments and they are evidently simple filaments at first in other genera as indicated in our studies of Anomia and Pecten.[1] The mantle border of the prodissoconch is free around its entire margins except at the hinge line in Ostrea, and bears no tentacles or siphons. A similar condition of freedom exists in the youngest stages we know of related genera, and the development of tentacles and eyes described in Pecten indicates that at a very early period the border was without them in that genus. A foot evidently exists in the typical prodissoconch, for though wanting in Ostrea,[2] it is present and highly developed at the close of the prodissoconch period in the young of many related genera (Avicula, Perna, Pecten, Anomia, etc.), as I have shown. The foot where known is marked by a proximal byssal cleft and a distal cleft which latter is flattened out when crawling, giving the foot a disc-like, clinging power (see Pecten and Anomia, sections IX and XII).

With the above described prodissoconch features as known characters we have to seek for possible kinship with ancient forms. These characters are found to be combined in a remarkable degree in the ancient genus Nucula which, though living to-day, extends back to very early fossiliferous formations, fifty species (Tryon) being known from the palæozoic. Nucula is one of the few genera known which has the umbos of the shell directed toward the posterior end of the body.[3] The shell of Nucula is oval, nacreous, not prismatic[4] and has a curved hinge line with teeth at right angles to its axis. A triangular, central cartilage pit is a characteristic feature of the Nuculidæ, and though it is not definitely known to exist in the prodissoconch it may exist at that stage in some genera, and is a marked feature of the succeeding dissoconch in all the ascendent series

[1] A simple, filamentous condition of the gills as first described by Lacaze-Duthiers in Mytilus is considered by embryologists as characteristic of all developing Pelecypoda.

[2] The absence of the foot in Ostrea is fully discussed in previous pages.

[3] The only genera outside the Nuculidæ, in which the umbos are directed posteriorly as far as I have found from the conchological manuals, are Anatina, Donax and Tellina, the two latter belonging to one family.

[4] Traces of prismatic cellular structure are noted in Nucula by Carpenter, but he equally notes it in many other genera of Pelecypods, as sometimes seen in slight patches though not a feature of the shell as in Avicula, etc.

of the Avieulidæ and their allies. Nucula is dimyarian, an addnctor muscle existing at either end of the equal valves. The gills are in two pairs, composed of simple, disunited filaments[1] (Mitzukuri). The mantle borders are plain, without tentacles or a siphon, and free around the margins. The foot is marked by a longitudinal cleft; accordingly it can be flattened into a circular disc (Mitzukuri) and it has been observed crawling up the sides of a glass of sea water (Tryon) indicating considerable clinging capacity of the foot. All these characters coinciding so closely with the features of anatomy and shell structure known in the prodissoconch, together with the fact that Nucula is known in very early fossiliferous formations combine to render it extremely probable that Nucula or a Nuculoid form is the type we are seeking as the early ancestral radical represented by the completed prodissoconch in the development of Avicula, Perna, Ostrea, Pecten, Anomia and their allies.

The fact that Nucula is found in the Lower Silurian formations and still lives up to the present day without sufficient changes in its shell structure to make these extremely separable forms in time generically separable, argues strongly for a very high antiquity for this genus. It was so firmly established in its earliest known forms that it must at that time have been an ancient genus. It may therefore well have been the primitive ancestral radical toward which the prodissoconch of the genera under consideration points as the archetype, still indicated in the development of a modern individual.

I have, therefore, from the results of these studies been able to trace, to Nucula or a Nuculoid form as a probable type-ancestor, the prodissoconch which I have found to be characteristic of developing Avicula, Perna, Ostrea, Pecten, Anomia and their allies. In the next section (XVI) the relationship existing between these several genera and their allies is traced as far as I am able to do so with my present understanding of the groups.

XVI. Genealogical Connection of the Aviculidæ and their Allies.

It is shown in section XV that the prodissoconch, which is characteristic of the Avieulidæ and their allies, as represented by typical genera, can be traced to Nucula or a Nuculoid form as a probable ancestral radical of the whole group. In this section later stages of shell growth are considered in their phylogenetic bearing and a tabular view is given which represents the genealogical connection of the several genera as it is understood from the results of these studies. Frequent reference is made to the preceding text for a full consideration of points only briefly alluded to, and many genera not previously studied are introduced.

The early nepionic stage of Avicula, figs. 32–33, p. 330, Perna, Pl. XXVII, fig. 1, and Pecten, Pl. XXVIII, fig. 9, is closely alike in many species, indicating a common line of ancestry for these genera. The points of resemblance are as follows:—The body of the shell is sub-rhomboidal, oblique, the hinge line straight; the posterior wing is rounded and is not produced beyond the margin of the body of the shell. Anteriorly the straight hinge extends beyond the limits of the prodissoconch, and is terminated by a moderate auricle as in Avicula and Pecten, or the auricle may descend directly from the umbonal area without any anterior extension of the hinge line as in Perna. In the several genera

[1]Nucula has been considered a primitive prototypal Pelecypod by several investigators on account of the simplicity of the gills, which are paralleled in the early stages of many genera of Pelecypods.

the ligament joins the valves on the hinge line and a triangular cartilage pit extends inwards from the limits of the prodissoconch valve as shown in young Perna, fig. 30, p. 329. Teeth may exist on the hinge line as in Avicula and Perna, or not, as in Pecten. The right valve in the young of these genera has a byssal sinus originating in the initial stages of the dissoconch growth on the border of the prodissoconch valve, thence progressively produced to the free border of the valves, fig. 33, p. 330; Pl. XXVII, figs. 2, 3, 7, 8, 9, and Pl. XXVIII, fig. 10.

The form of the young shell as above described is found to be closely similar to that characteristic of the adults of many Aviculoids from the Lower and Upper Silurian formations. Especially is it comparable to early Aviculoids figured by Barrande. These early forms differ widely from Avicula and require one or more distinct generic names. The Devonian Aviculoids have been subdivided generically by Professor Hall, but none of his genera suffice to cover the types which are here referred to. I would, therefore, introduce a new genus — Rhombopteria.

Rhombopteria, gen. nov.[1] A group of Lower and Upper Silurian Aviculoids, in which the shell is sub-rhomboidal, oblique, with umbos in the anterior half. The hinge line is straight, less than the length of shell, and is commonly produced anteriorly as well as posteriorly from the umbos. The borders of the valves posteriorly descend in a curved line from the terminus of the hinge without having any posterior extension of the wing. Anteriorly the borders of the valves descend from the hinge, forming an auricle close to the hinge line. In some species the auricle may be in close proximity to the umbos without any anterior extension of the hinge line, as in *Rhombopteria (Av.) glabra*, sp. Munst. Two adductor muscles and lateral teeth exist in closely related forms and probably are characteristic of this genus; but the features are not definitely known. It is quite possible, also, that a cartilage pit exists, although it also is not known, as the internal characters of the genus have not been ascertained. Type — *Rhombopteria (Av.) mira*, sp. Barr., fig. 51. For other figures of this species see Barrande's Système Silurien de la Bohème, Vol. VI, Pl. 226. Besides the type several species figured by M. Barrande come under the genus Rhombopteria, among which should be mentioned: *R. pseudomira*, sp. Barr.; *R. cognata*, sp. Barr.; *R. scala*, sp. Barr.; *R. patricia*, sp. Barr. and *R. glabra*, sp. Munst, all of which are figured on Plates 226–228 inclusive.

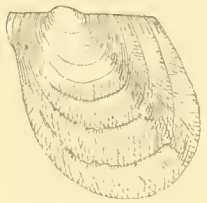


FIG. 51 — *Rhombopteria mira*, formation E (upper Silurian), système Silurien. (After Barrande.)

Rhombopteria is the nearest approach to a primitive Aviculoid that has been found in studying fossil species. Not only can the nepionic stages of modern Avicula, Pecten and Perna be closely compared to this type, but camera drawings of the young of Aviculopecten, Leptodesma and other palæozoic and mesozoic allied genera bear a close resemblance to Rhombopteria as well. The American Lower Silurian species, *Avicula? trentonensis*, Con., *A.? gregaria*, Ulrich, and *A.? demissa*, Con., are near allies of Rhombopteria, especially the species *trentonensis*. In Aviculoids as a rule, the younger the specimen or the older the geological formation from which a specimen is obtained the nearer does it approach to the features of the genus Rhombopteria. In the comparisons of young Avicula, Perna, Pecten, etc., to Rhombopteria, it will be observed that there

[1] ῥομβος, a rhomb, and πτερον, a wing.

is a discrepancy in that the right valve of these genera has a well defined byssal sinus, whereas no byssal sinus exists in any of the figures of Rhombopteria cited. Dr. Beecher writes me that young *Avicula? demissa* has a byssal sinus and this species is a near approach to Rhombopteria, especially when young, but differs in having the posterior wing produced in the adult. It is quite possible that species of Rhombopteria may be found which have a byssal sinus; but if no such species should be found, it would not seriously affect our comparison of young Avicnlas, etc., to this early type. The byssal sinus acquired in later periods of the development of a group might well be pushed back to the nepionic stages in the ontogeny of an individual by acceleration of development, also the existence of the character is quite variable in some genera, as in Aviculopecten.

The genetic relations expressed in the following pages and table must be looked at as a first attempt to classify the various groups and genera in their serial connections, for such I believe it is. Changes may and probably will be necessary in parts, but as a whole I believe it represents a close approximation to the true phylogenetic sequence of the genera considered.

The dimyarian prodissoconch characteristic of the early stages of this whole group is the representative in development of a dimyarian Nuculoid radical as discussed in section xv. Therefore a Nuculoid form makes a basis from which to start our phylogenetic series.

These studies tend to show that the primitive Avicnloid ancestor came off directly from the Nuculoid radical because the first nepionic stages of Avicula, Leptodesma, Perna, Pecten, Aviculopecten, etc., correspond closely with the earliest and simplest known Aviculoid. If intermediate forms existed between the Nuculoid radical and the earliest known Avicnloid, traces of it are not indicated in the shell, so that such possible transitional steps cannot be ascertained with our present knowledge. Therefore Rhombopteria, as the most primitive known Aviculoid, is considered the next step upward in the phylogeny of the group.

From this point up the phylogeny of the various groups is on divergent lines as expressed in the tabular view, and in the following pages we shall consider the groups in succession as indicated in the table, p. 391.

Leptodesma,[1] Hall, is a genus embracing a group of Devonian Aviculoids characterized by an oblique body. The posterior wing is more or less produced beyond the borders of the valves; anteriorly the shell is acute or nasute. The hinge is narrow with a slender, lateral tooth. The posterior adductor muscle is large, subcentral, but the anterior is not figured by Hall and is therefore presumably very reduced. The genus forms a natural passage from Rhombopteria to the true Avicnlas. As Professor Hall says, the species present a remarkable assemblage of forms. At one extreme the shell has a well-developed posterior wing, acute anterior border and byssal sinus closely resembling Avicula. From this extreme it passes " . . . through various phases in form, proportions, etc., until the wing becomes nearly obsolete, the byssal sinus obscure and the anterior end rounded. . . . " This other extreme brings the form very close to our genus

[1] For a consideration of this and other palæozoic genera I am greatly indebted to Professor Hall's fine work on Devonian Lamellibranchs in the Natural History of New York, Vol. v, Parts i–ii. I am also recently indebted to that venerable palæontologist for the opportunity to study his collections and types at Albany.

Rhombopteria. *Leptodesma orus*, Hall, is a species with a well-developed posterior wing but a camera drawing of the young is rhomboidal and bears much resemblance to Rhombopteria. The same comparison may be made in a degree by noting the differences in the younger and older specimens figured by Hall in several species as *L. matheri* and *L. jason* and it may also be observed by following the lines of growth in many of his figures. Leptodesma is therefore considered the next step in the ascendent phylogenetic series.

Avicula, the representative of the family, is clearly derived from Leptodesma-like forms. Using *Avicula hirundo*, L., the type species of the genus, as our basis of comparison we find that Avicula differs from Leptodesma in having a highly produced posterior wing, a deep byssal notch in the right valve, and small cardinal teeth. A more or less well-developed triangular cartilage pit exists in all Aviculas. In species with a narrow hinge line, as *A. sterna*, the pit is only prominent in the young; but in others, as in the sub-genus Meleagrina, it is a marked feature of the adults.[1] In the ontogeny of the individual we find that Avicula at the prodissoconch stage is referable in ancestry to the Nuculoid radical of the group. In the early nepionic stage, fig. 32, p. 330, it is referable to Rhombopteria; in the later nepionic stage, fig. 33, p. 330, a considerable wing has developed and the form approaches near to the winged Leptodesmas. Later still the full Avicula features are acquired. Thus the ontogeny of the individual represents very fully the phylogeny of the genus. The first appearance of true Avicula in the geological horizon is uncertain as many early types called Avicula certainly do not properly belong to that genus and the limitations of the genus in the past have not been fully ascertained. It probably is truly represented as early as the Devonian or Carboniferous. From Avicula many genera and sub-genera are derived, a part of which only we are prepared to discuss. (Further consideration of Avicula, see p. 330.)

Pseudomonotis. The young, as observed in *P. echinata*, has a prodissoconch and nepionic stage like the same period of Avicula, figs. 32–34, p. 330. Later, the hinge line becomes relatively shorter and very moderate abbreviated wings are differentiated. Monotis occurs later in time and has features closely comparable to Pseudomonotis, therefore it is considered provisionally as derived from that genus. Daonella and Halobia are genera which are sub-rhomboidal in form and present a high reduction of Aviculoid characters. They are unquestionably side-issues off the ascendent line of the group and should probbly be associated with Monotis or Pseudomonotis, but as I have not had specimens for study they are not further considered. (Further description of Monotis and Pseudomonotis, see pp. 331, 332.)

Oxytoma, a genus near to Avicula, has a short hinge line with moderately developed ears and a slight obliquity of the body of the shell. It seems to be a variation from Avicula, in the same line as Monotis and Pseudomonotis. Some features of the young are shown in Pl. XXVII, fig. 7. (Further description of Oxytoma, see p. 332.)

Cassianella is highly inequivalvular; the young has a prodissoconch and nepionic stages like the young of Avicula, as shown in *C. decussata*, fig. 35, p. 332. The hinge line is of moderate length, the wings are moderately produced and cardinal teeth are

[1] A cartilage pit is characteristic of the Pecten division of this group and it is probably characteristic of Rhombopteria and Leptodesma. In all it may be inherited from the Nuculoid ancestor in which it is a characteristic feature.

well developed. Provisionally, Cassianella is considered a branch from Avicula, in the same line as Pseudomonotis, etc. (Further description of Cassianella, see p. 332.)

Vulsella, when young, fig. 36, p. 332, bears a considerable resemblance to young Avicula, fig. 32, p. 330, as it has a similar prodissoconch and nepionic rhombic form. Later, the resemblance is lost, as wings are wanting, the hinge line is highly reduced and often produced in a curve around the deeply-sunken cartilage pit. Vulsella is evidently a side-issue from the Avicula stock and provisionally is placed on the same branch as Malleus.

Malleus is a genus closely allied to Avicula. The main features of difference are the great development of prismatic cellular tissue, loss of teeth, deep cartilage pit and contorted form. In the young it resembles Avicula, as pointed out by Woodward. It should be observed, however, that it is the young of Avicula, fig. 32, p. 330, which the young Malleus most nearly resembles, as shown at the umbonal region or early growth of fig. 52. The irregular, contorted growth of adult Malleus, Pl. XXVII, fig. 19, and also the relative great development of prismatic cellular tissue and extreme reduction in area and thickness of nacreous tissue, are features of the adult which point toward the probability that Malleus is a degenerate or retrograde genus.

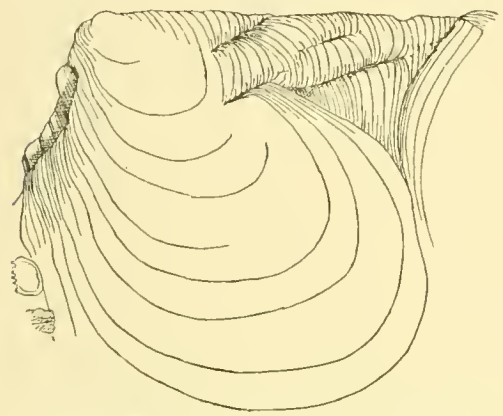


FIG. 52.—*Malleus vulgaris*, L. Tip of left valve showing the form of the young. × 13 diam. (Drawn by the author.)

On another line of descent we find Meleagrina. When young it resembles young Avicula, fig. 32, p. 330, but it has then no teeth. The cartilage pit descends from the limits of the prodissoconch as in Avicula and Perna, fig. 30, p. 329. With increasing age the oblique form of the body of the shell decreases and the characteristic rhombic form of the adult progressively increases. The rhombic form characteristic of the adults of this and some other genera is not necessarily to be considered as an inheritance from Rhombopteria. It is rather an approach to a form normal to the group and which is frequently repeated in genera not closely akin. (Further description of Meleagrina, see p. 331.)

Perna is an unquestionable branch from Avicula. The nepionic stage of Perna, Pl. XXVII, fig. 1, is similar to the same stage of Avicula, fig. 32, p. 330, the main difference being that the anterior auricle descends directly from the prodissoconch without an anterior extension of the hinge line. At this age but a single triangular cartilage pit exists, fig. 30, p. 329, and cardinal and lateral teeth like those of Avicula underlie the hinge line. Later, new cartilage pits develop on the hinge line, fig. 31, p. 329, and in successive growth they assume the perpendicular form characteristic of the pits of the genus, Pl. XXVI, fig. 16. The number of pits is variable, but twenty or more exist in some fossil species. Wings may or may not develop in Perna, Pl. XXVI, figs. 16–18, but the body of the shell is produced obliquely or vertically as in Avicula or Malleus, Pl. XXVI, fig. 19. In no species are teeth known in the adult and they seem to be purely hereditary characters limited to early stages of development. The microscopic shell structure of Perna is identical with that of Avicula, and the anatomy of the two genera is alike as far as

observed. The numerous and peculiar cartilage pits, loss of hinge teeth and form of the shell point out clearly that Perna is a side branch, off the ascendent line of the Aviculan series. In these studies Perna is considered the main stem from which important branches are given off. (Further description of Perna, see pp. 326, 327.)

Bakewellia appears to be a branch from Avicula, in the same line of variation as Perna, on account of the series of cartilage pits. The form of adult Bakewellia is very similar to the young of Perna, Pl. XXVII, fig. 1, so that it might appear to be in the line of ancestry of Perna. An objection to this assumption is the high development of both adductor muscles, whereas neither Avicula nor Perna has more than a slight development of the anterior adductor. A dimyarian condition has been shown to be characteristic of the prodissoconch stage of Ostrea, Pecten, Avicula, etc., and in Bakewellia, we merely have to assume that the early anterior adductor was retained instead of abandoned in the ontogeny of the individual. A similar case of the retention of the anterior adductor is seen in Dimya, which has two adductors in the adult though belonging to a typical monomyarian group. The form of Bakewellia is sub-rhomboidal, oblique and is quite comparable to Rhombopteria. The cartilage pits, primitive form of the valves and large anterior adductor muscle, point to the conclusion that Bakewellia is a specialized and partially retrogressive genus.

Gervillia has important characters of form and cartilage pits connecting it with Perna from which genus it was probably derived. Hornesia, an allied genus, is apparently a modified branch from Gervillia differing principally in its inequivalvular form.

Inoceramus was probably derived from Perna, through the intermediation of Gervillia. The forms of the genus which are rhomboidal and the most equivalvular, as *Inoceramus crispi*, Mant., are to be considered the more normal, least modified forms of the genus as they approach nearest to the condition found in ancestral genera. The oval and plicated genus Actinoceramus is a modified branch from Inoceramus. Volviceramus is a still more modified, oval and highly involute genus probably derived from Actinoceramus.

Pernostrea from the Jurassic is a descendant of Perna which attached itself by the umbo of the left valve and the consequent conditions of fixation modified the shell, inducing an ostrean form. The shell has a series of cartilage pits like Perna and a form which closely resembles an oyster. (Further description of Pernostrea, see p. 325.)

From the studies on the development of the oyster, sections IV–VII, we have come to consider Ostrea as close akin to and derived from Perna (pp. 326–327). The points of likeness are features in the anatomy of the soft parts, the prodissoconch and the structure of the right, free, least modified valve. The points of difference are the absence of the foot, the highly modified attached valve and the single cartilage pit of Ostrea. The first two features of difference are paralleled in Pernostrea and are ascribed to the effects of the condition of cemented fixation (section VII). The oyster is a highly modified form and the reduction of the several cartilage pits of Perna to a single one in Ostrea is considered as part of the specialization of the genus. When young, Perna also has but a single cartilage pit like the oyster; compare fig. 30, p. 329 with Pl. XXIV, fig. 19. Ostrea is the least modified member of the Ostreadæ, as it nearest approaches to Perna from which it was apparently derived. Gryphæa is a more highly modified genus and

Exogyra is the most highly modified member of the family. Therefore they are considered as derived from Ostrea and are in the ascendent series of this peculiar group. The marked sinuosity in the left valve of Gryphæa and Exogyra is compared to a similar sinuosity in young Ostrea, Pl. xxv, figs. 5–6, and is ascribed to the local retraction of the mantle border at that area where excurrent action takes place (p. 307).

Exogyra is compared to the adult of species of Chama (the base of the Chamidæ) and to the young of Caprinula, Pl. xxv, fig. 20, Hippurites and Radiolites (extremes of the same group) which in external form it closely resembles. The form of all these genera is believed to be built up as the result of cemented fixation with its accompanying influences of environment. When a Pelecypod becomes attached by cemented fixation the first form induced by the new conditions is a form like Ostrea. A further modification in this line of variation is a form like Exogyra. The next step in the same line of variation is a form like Caprotina or Caprinula, Pl. xxvi, figs. 10 and 8. Finally the last step in the same line of variation is a form like Hippurites or Radiolites which are conical or cup-shaped with a considerable degree of superficial radial symmetry (see section vii, and especially foot-note, p. 322).

Alectryonia which is strongly plicated in both valves and adherent by recurved clasping spinous processes, is undoubtedly a side issue from Ostrea and not in the ascendent line of the family.

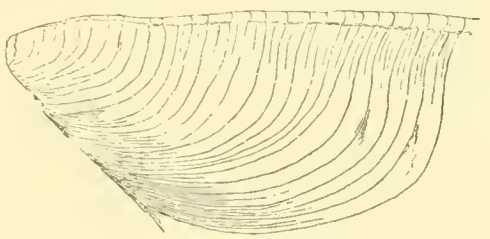


Fig. 53.—Tip of young *Pinna, sp. indet.* from Panama. Original in Yale University Museum. Cat. No. 2327. ×4 diam. (Drawn by the author.)

I have not had opportunity to study the Pinnidæ satisfactorily as attempts to obtain very young specimens have so far failed. The following is offered as the probable genetic relations of the family. Palæopinna (Hall) in form is not far removed from some species of Leptodesma and it can be naturally derived from that genus by reducing the posterior extension of the wing and increasing the length of the antero-posterior axis. From Palæopinna or Aviculopinna to Pinna, is a natural step introduced by an increased acuteness anteriorly and a greater curvature of the lines of growth posteriorly. In support of this view we find that young Pinnas (20 mm. more or less in length), fig. 53, are obtuse anteriorly, and posteriorly have an obtuse abbreviated extension of the hinge line, like Aviculopinna. These features gradually fade out in succeeding growth and give place to the acute anterior and roundly curved posterior border of the valves which is characteristic of the genus. The Pinnidæ should, I believe, be considered a degradational group because of the great development of prismatic cellular tissue and loss of nacreous tissue (a weakening character), loss of teeth on the hinge line, and relatively large development of the anterior adductor muscle (a larval character, highly reduced or wanting in the ascendent series of related groups).

Atrina is a peculiar genus of the Pinnidæ of twisted irregular growth. In the later growth of the shell there is a direct fusion of the two valves both on the dorsal and ventral border though in less degree on the latter. In a specimen of *A. saccata* sp., L. in my collection, 114 mm. in length, the fusion dorsally occupies a length of about 50 mm.

and in this area the lines of growth pass directly across from one valve to the other without any indication of the hinge line. The nacreous tissue is highly reduced in extent. The shell has become in a physiological sense a flattened tubular univalve which may be compared in a measure in its resultant form to an Aspergillum (*vide* note 3, p. 376). In the young of Atrina the two valves are perfectly separable and have not yet acquired the twisted abnormal features characteristic of the adult. Atrina should be considered a very retrograde genus as it is weak and abnormal to a high degree.

Trichites, another genus derived from Pinna, is peculiar for its excessive development of prismatic cellular tissue which may reach an inch or more in thickness. It is an extreme modification of the Pinnidæ of highly irregular growth and without hinge teeth. The great development of prismatic cellular tissue in the Pinnidæ disproves the statement commonly made in text-books that this structure is only formed by the edge of the mantle. The formation of prismatic tissue commonly is limited to that portion of the shell built by the edge of the mantle, as in Avicula, Ostrea, Anodon, etc., the deeper-seated portions of the mantle in such cases building nacreous or sub-nacreous tissue. In Pinna, Atrina, Trichites and Malleus, however, the deeper seated parts of the mantle as well as distal edges must build prismatic tissue or this structure would not attain the thickness that it does, and further we may actually see in fresh specimens that the nacreous structure, as in Atrina and Malleus, is limited to a very small area near the umbonal portion of the shell.

Pterinea is closely related to Aviculoid types and yet is not in the ascendent line of Avicula proper. The shell is nasute anteriorly and the wing may or may not be produced posteriorly. The ligamental area of the valves is striated longitudinally (compare with Meleagrina); but no cartilage pit is differentiated, although this is characteristic (either as a single or several pits) of Avicula and all its various descendants as represented in the accompanying table. The young of Pterinea as shown by Goldfuss[1] in *P. lævis* is rhombic in form and bears a very close resemblance in contour to Rhombopteria, fig. 51, p. 380. Pterinea is considered as a side branch, probably derived from Rhombopteria.

Actinopteria (Hall) and Ptychopteria (Hall) are genera described by Professor Hall as differing from Pterinea in the absence of a strong striated ligamental area and in the absence of cardinal and lateral teeth. Following his figures and descriptions, it is seen that Actinopteria more nearly approaches to the characters of Pterinea than does Ptychopteria; therefore, in our table they are arranged in that serial order. Both genera appear to be on a side branch from Pterinea; not in a direct line of ascent because they are characterized by a loss, not an accentuation or modification of Pterinean features.

Pterinopecten (Hall), a Devonian genus of the Aviculopecten group, is characterized by a long hinge line, with ears not well defined, being simple expansions or extensions of the hinge line. The various species are frequently described by Hall as sub-rhomboidal, especially when young, and he mentions that some species resemble the young of Aviculopecten and Lyriopecten. *Pterinopecten dignatus*, Hall, *P. conspectus*, Hall, and similar species bear a close resemblance to the young of *Pecten irradians*, Pl. XXVIII, figs. 12–13. They resemble the figures cited in both valves as the right valve has a deep byssal sinus. The young of Pterinopecten is similar to the adult of Rhombopteria as I have observed in *P.*

[1] Petrefacta Germaniæ, Pl. CXIX, fig. 1*a*.

intermedius, Hall, *P. vertumnus*, Hall, and *P. conspectus*, Hall. Pterinopecten is naturally derived from Rhombopteria by the introduction of slight ears on the hinge line. It is the simplest known form of the Pectenidæ and is traceable in the early stages of development of Aviculopecten and Pecten; therefore, I shall consider Pterinopecten as directly descended from Rhombopteria and as the base of the Pectinidæ from which all later forms were derived. (Further discussion of Pterinopecten, see p. 346.)

Aviculopecten (McCoy), as amended by Hall, includes forms with a hinge usually shorter than the transverse diameter of the shell and with both ears well defined. A cartilage pit is described by Hall in several species of this genus, also in Lyriopecten and other allies. A deep byssal sinus occurs in the right valve of many species of Aviculopecten and diverging furrows exist on the hinge line in some species similar to those found in certain recent Pectens as *P. maximus*. A finely preserved specimen of *Aviculopecten fasciculatus*, Hall, shows that when young (3 mm. in height) the shell was rhomboidal and in its general contour, resembled Rhombopteria. During later growth a long hinge line and moderately developed ears develop, making the shell at this stage comparable to Pterinopecten; later still, the characters of a shorter hinge line and pronounced ears give the shell the characters of the genus Aviculopecten. Similar observations have been made on the development of *Aviculopecten princeps*, Hall, and a few other species. Aviculopecten, when young, resembles Pterinopecten and when adult resembles the young of Pecten, Pl. XXVIII, fig. 2. It is, therefore, unquestionably intermediate between these two types. (Further discussion of Aviculopecten, see p. 346.)

From Aviculopecten we pass to Pecten in the direct line of ascent. Pecten has a relatively short hinge line, both ears well defined, but the ventral (anterior) a little larger; either a slight or no byssal sinus exists in the ear of the right valve. The ligament and cartilage are as in Aviculopecten. In the development of *Pecten irradians* and other species (sections IX–X) we have shown a remarkable series of phylogenetic characters which may be briefly alluded to. The prodissoconch, *p*, of Pecten is dimyarian, Pl. XXVII, figs. 8–9, Pl. XXVIII, figs. 9–10, and is traced to the Nuculoid radical of the whole group (see table). The first nepionic stage, Pl. XXVIII, fig. 9, is rhomboidal, oblique, and is traced to Rhombopteria; the later nepionic stage, Pl. XXVIII, figs. 12–13 has a long hinge line, and ears which are simple expansions of the hinge margin; these features and the deep byssal sinus are traceable to Pterinopecten. The nealogic stage of Pecten, Pl. XXVIII, fig. 2, has a relatively shorter hinge and well developed ears, and this stage is traceable to Aviculopecten. Only when the individual has advanced considerably in age are the full characters of the adult, fig. 37, p. 333, acquired. The first appearance of Pecten geologically is doubtful as the limitations of the genus among palæozoic fossils has not been fully worked out. All of Professor Hall's Devonian Pectinidæ are, however, referable to other genera and we will provisionally consider Pecten as dating from the Carboniferous. From Pecten as a base many genera have sprung as will be presently considered.

Lyriopecten (Hall) differs from Aviculopecten in possessing a short hinge and a small anterior ear. It also differs from Pecten in this last character and it is considered as a side branch from Aviculopecten. In support of this view we find that a specimen of *Lyriopecten orbiculatus* Hall, which had a short hinge in the adult, in the young (as ascer-

tained by following the lines of growth) had a long hinge line, with a comparatively slight development of the ears.

Crenipecten, Hall, is a genus like Aviculopecten in form, but with crenulations on the hinge margins. Pernopecten, Winchell, has a large triangular cartilage pit and a crenulated hinge plate. The crenulations in these genera are described as cartilage pits. A crenulated hinge plate is found in the young of *Pecten tennicostatus*, fig. 38, p. 348, and *P. monotimeris*. It has also been found more or less developed in the young of several recent species of Pecten by Dall (16). He considers the crenulations as an order of dentition[1] and the crenulations in the fossil genera cited are probably of similar significance. As evidence against the view of considering them as cartilage pits, it should be observed that in Perna, etc., where numerous cartilage pits are typical, the primitive pit as well as succeeding ones assumes the perpendicular sides characteristic of the pits of the genus, figs. 30–31, p. 329, and Pl. XXVI, fig. 16. Crenipecten and Pernopecten are considered as side issues from Aviculopecten.

Lima has many features of anatomy and shell form linking it with Pecten; it is, therefore, presumably a side issue from the early members of this genus. (Further description of Lima, see p. 353.)

The genus Chlamys (Bolton), characterized by the great development of the ventral (anterior) ear and correlated reduction of the dorsal ear, is an undoubted branch from Pecten. When young, Pl. XXVIII, fig. 14, both ears are nearly equally developed as in Pecten. Chlamys is a swing in one direction as Lyriopecten is a swing in the other direction, for the latter has the anterior ear very reduced and the posterior ear largely developed. (Further description of Chlamys, see p. 348.)

Vola (Klein) is a near ally of Pecten; in the adult it is highly inequivalvular, the right valve is deeply concave, while the left valve is flat or even slightly concave. When young, however, it is nearly or quite equivalvular. In a finely preserved specimen from Japan, a prodissoconch and nepionic stages were observed in both valves, similar to those characteristic of *Pecten irradians*, Pl. XXVIII, figs. 9–12.

Amusium (Schumacher) (see Dall) is characterized by radiating, internal ribs, a short hinge line, nearly equal ears and a high reduction or complete absence of the byssal notch. The ears of the right valve may be produced beyond the limits of those of the left, on the hinge border, as in *Amusium japonicum*, thus making an abbreviated approach to the condition characteristic of the genus Entolium, Meek. Commonly a pair of ridges diverge from the hinge line and terminate in tubercular processes close to the auricular sinus of either ear. Dall has named them auricular crurae. Crurae similar to those of Amusium may be traced in most species of Pecten, though they are often very reduced, the terminal tubercle at the auricular sinus alone existing. The function of the crurae is not understood. Dr. Dall, in his studies of deep-sea Amusium, notes the existence of prismatic structure in several species, in which, however, it was not limited to the right valves, as shown in our studies of young Pecten (section X). Amusium is considered a side issue from Pecten, rather than in the line of ascent of the group.

Anomia is doubtless a side issue from Pecten as discussed (section XIII). In the young there is, as in Pecten, a deep byssal sinus in the right valve, Pl. XXIX, fig. 6.

[1] See reference to a paper by W. H. Dall, foot-note, p. 376.

Later the byssal sinus becomes enclosed to form the byssal foramen as described (fig. 41, p. 354). The peculiarity of the shell and many features of anatomy are clearly attributable to the special conditions of environment of the animal (full discussion, sections XII–XIII).

Ænigma is an extreme modification in the Anomia line of variation. The right valve is very attenuated, the umbos are far removed from the hinge line, and the byssal foramen is sub-central. A specimen of *Ænigma ænigmatica*, Chemn., in my collection is obliquely oval, closely resembling the form found in young Anomia, Pl. XXIX, fig. 5. The left (upper) valve from the umbo to the periphery of the shell shows the fusion of the lines of growth that takes place at that area as in young Anomia, Pl. XXIX, fig. 8. Ænigma, therefore, though with full probability a descendant of Anomia, in some characters resembles the nepionic period of that genus.

Placunanomia differs from Anomia in the calcareous union of the borders of the byssal foramen anteriorly; it also differs in the development of diverging lamellæ from the hinge border. By the encroachment of the borders of the byssal foramen the byssus in later life tends to become solidly fixed in the lower valve. In *Placunanomia macrochisma*, Desh., the byssal foramen is open in specimens two inches in height and is only partially closed in specimens somewhat over four inches in height, as far as observed in the few specimens at command. In the single specimen of *Placunanomia rudis*, Brod., observed, the byssal foramen is entirely closed. Placunanomia is off the direct line of ascent in the Anomia order of modification, and is transitional between Anomia on one side and Carolia and Placuna on the other, as demonstrated by Fischer.

Carolia is a genus which seems clearly to be intermediate between Placunanomia and Placuna, as demonstrated by Fischer. When young, Carolia has a deep byssal sinus like adult Anomia. Later the sinus becomes progressively deeper like Ænigma, then the borders of the notch become joined on the anterior border like Placunanomia and finally the byssal foramen is cut off by shelly growth, when the shell approaches to the condition of Placuna.

Placuna in its anatomy is essentially like Anomia but the mantle border has a curtain, like Pecten, as shown by Woodward. The structure of the shell is also very similar to Anomia. In the New York State Museum I observed an inclosed byssal plug in young specimens of *Placuna sella*. The plug occupies the base of a foramen which is filled up by calcareous growth similarly to Anomia; but in the specimens observed the plug was already cut off from the body of the animal by a calcareous secretion that had taken place on the proximal side of that area. A similar condition to that observed in *Placuna sella* is described and figured by Fischer in young *P. papyracea*. The cruræ of Placuna, though existing only in the right valve of the adult (the left valve having corresponding depressions), are equally developed in both valves of the young. The cruræ of Placuna seem to be a modification and posterior extension of the knob-like cartilage support found in the right valve of Anomia. (Further discussion of Placuna, see p. 362.)

Dimya, on account of some features of anatomy and shell structure, is placed by Dr. Dall near to Pecten. The shell being ostreaform, he considered that the genus lay between Pecten and Ostrea. I have shown I think conclusively that the ostrean form of

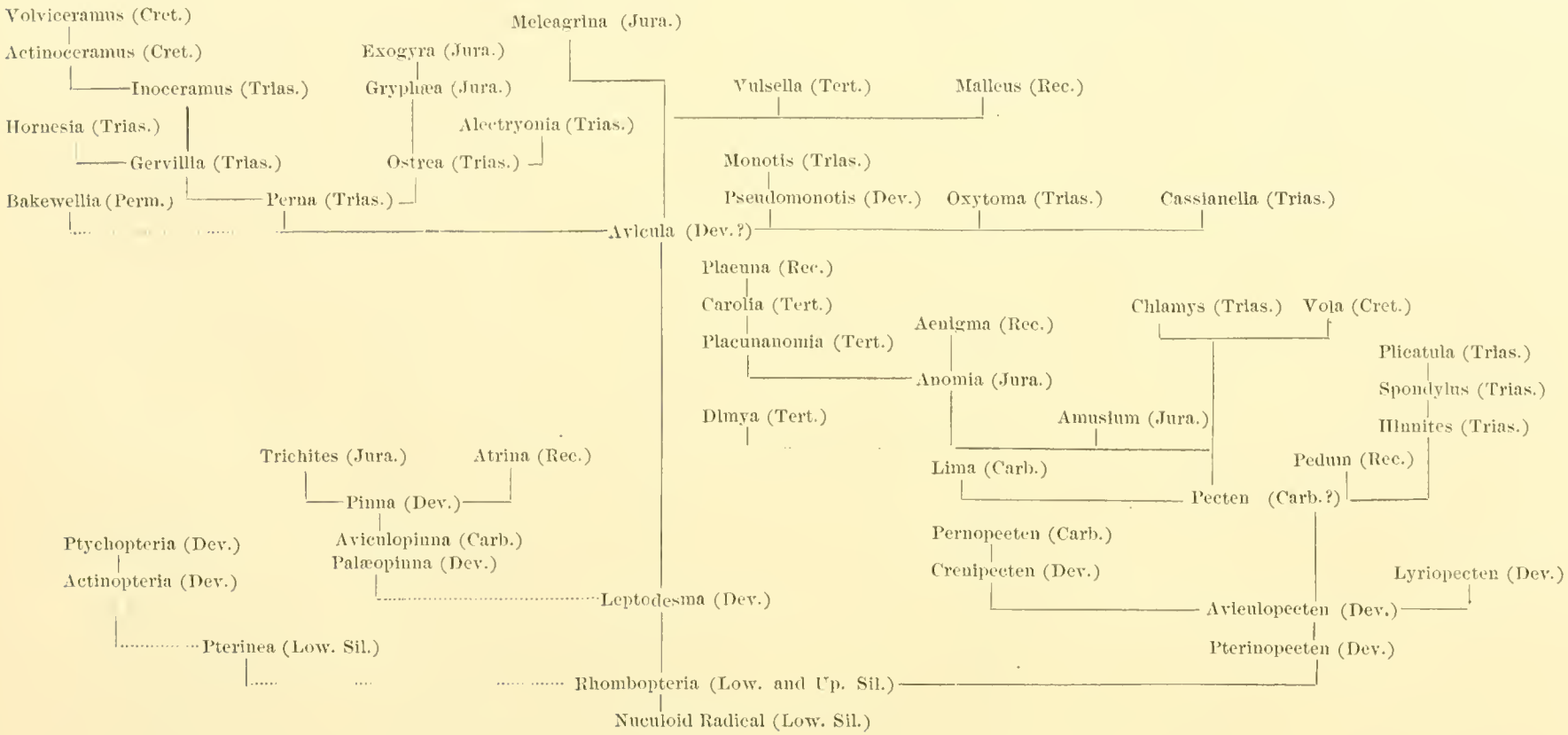
shell is induced by the conditions of fixation in any attached Pelecypod; therefore Dimya should be considered as a highly modified branch from Pecten, which is ostreaform because attached. It is shown in this paper that the prodissoconch of Ostrea, Pecten, etc., is dimyarian, therefore we may fairly infer that the existence of two adductor muscles in adult Dimya is due to the retention of both muscles which are doubtless existent in the prodissoconch stage of that genus. It is to be noted also that the gills of Dimya are in an archaic condition of simplicity as described by Dall. It is shown in the table of genera, p. 391, that Pecten and Ostrea are very widely separated genera, therefore no one genus can properly be considered as intermediate between these two types. Dimya is considered as a side-issue from Pecten, possessing many archaic and modified features which render it a highly retrogressive or degradational form. (Further description of Dimya, see pp. 306, 324.)

Pedum is evidently a descendant of Pecten. In the nepionic period, Pedum is purely pecteniform in both valves, not yet having acquired the peculiarities of the genus. Later, the byssal sinus is enclosed so as to become, in a measure, foraminal, and the shell is apparently closely related to the object of byssal attachment. The right valve is the most highly modified, although both valves are modified, and in the adult condition bear little resemblance to Pecten. The peculiar form of the shell of Pedum, it may be reasonably inferred, is due to the habit of close byssal fixation.

Hinnites, as already discussed, is an important genus in our conclusions. Up to the nealogic period, it is free or attached by a byssus and pecteniform, Pl. XXVI, figs. 3–4. It then becomes permanently attached by soldering the right valve to an object of support and with this change in habit we find that the irregular ostreaform growth is introduced as fully discussed (section VII). Hinnites is an undoubted descendant from Pecten and owes the peculiarity of its form to its adopted habit of fixation. (Further description of Hinnites, see pp. 324, 350.)

Spondylus, like Hinnites in its nepionic stage, is pecteniform, Pl. XXVII, fig. 4; then becoming attached at this early stage, the irregular growth characteristic of the genus is introduced and the shell becomes spondyliform. The right attached valve is the most highly modified, and the left valve is the least modified and nearest approaches to Pecten in form (discussed in sections VII and XI). Spondylus is considered as descended from Hinnites and is more highly modified than that genus because it earlier adopts the condition of fixation. The degree to which a talon is developed in Spondylus varies, being least developed in species which are most nearly equivalvular (p. 352). The peculiar interlocking teeth of Spondylus are believed to be a modification of the auricular cruræ characteristic of most Pectens and especially Amusium. The several teeth of Spondylus in the young seem directly traceable to the knob-like processes of the cruræ existing at the auricular termination of the cruræ in Pecten. In Spondylus apparently by the shortening of the cruræ, the distal knobs of the same are brought in close proximity to the hinge line, where they are further modified so as to produce interlocking, articulating processes. If this assumption in regard to the teeth of Spondylus is correct, they are teeth of different morphological nature from ordinary cardinal teeth and are to be compared to those only as to mechanical equivalents. (Further consideration of Spondylus, see pp. 318, 323 and 351.)

GENEALOGICAL TABLE OF THE AVICULIDÆ AND THEIR ALLIES.



Plicatula is an undoubted ally of Spondylus, as usually considered. As we have shown, the shell of Plicatula becomes attached at the close of the prodissoconch stage, and at once assumes the ostrean form, thus eradicating features of the nepionic stage which (as in Spondylus and Hinnites) might render that stage comparable to Pecten. Plicatula is considered the farthest removed from Pecten of its group, for in it the ostrean form is earliest acquired and most completely emphasized in the shell. (Further description of Plicatula, see p. 352.)

The table on the preceding page represents graphically the genetic relations expressed at various places in this paper and especially in the present section. When genera are considered as derived from other genera and in the ascendent line of the group, they are placed directly over one another, as in the case of Gryphæa and Ostrea. When a genus is derived from another, but is not considered as in the ascendent line of the series then it is placed as a side branch, as Alectryonia from Ostrea. Broken lines are used where the affinities expressed appear to be open to doubt. With each genus is expressed in brackets its earliest geological appearance, the data for these statements being for the most gathered from Zittel's Palæontology. The following abbreviations are used: Low. Sil., Lower Silurian; Up. Sil., Upper Silurian; Dev., Devonian; Carb., Carboniferous; Perm., Permian; Trias., Triassic; Jura., Jurassic; Cret., Cretaceous; Tert., Tertiary; Rec., Recent.

ERRATA.

Page 281, note, the prodissoconch is described in a few genera not included in this list. For such additions see sections VIII, X and XIV.

Page 291, paragraph 5, line 5, for *Apysia*, read *Aplysia*.

Page 291, paragraph 6, attention should have been called to Dr. W. Branco's monograph: Beitrage zur Entwickelungsgeschichte der fossilen Cephalopoden. Palæontographica, B. 27, 1880–81.

In section IV, at several points the oyster is spoken of as showing concentration of development, or as a concentrated type. In these cases for *concentration*, or *concentrated*, read *acceleration*, or *accelerated*, as that word is more in accord with the principle involved.

Page 314, line 14, for *overlying*, read *underlying*.

Page 330, line 5, for *Leioptera*, read *Leiopteria*.

Page 333, line 8, from bottom of page, for *shortening its length. It*, read *then shortening its length, it*.

Page 334, paragraph 3, line 13, for *exists*, read *were existent*.

Page 335, paragraph 3, line 10, for *at that time*, read *therefore*.

Page 336, paragraph 3, line 8, for *specimen if kept*, read *specimen kept*.

Page 336, paragraph 3, line 12, for *condition*, read *stage*.

Page 337, paragraph 2, line 4, for *If one break the byssus loose it*, read *If the scallop breaks loose, the byssus*.

Page 338, paragraph 2, line 6, for *over*, read *at*.

Page 345, line 6, for *Actinoptera*, read *Actinopteria*.

Page 361, description of cut, for *60*, read *30*.

Page 366, line 3, for *adults*, read *young shells*.

Page 370, paragraph 3, line 12, for *VIII* read *VII*.

XVII. LIST OF PAPERS QUOTED OR REFERRED TO IN THE TEXT.

In the text, numbers in parentheses referring to this list are appended to references when there is need of it, as when there are several references from one author in this list, or when with few references, there might be ambiguity as to which one is referred to. When but one reference is given in the list, or the reference intended is clear from the context, no number is appended in the text.

1. Adams, H. & A. Genera of Mollusca. London, 1858.
2. Balfour, F. M. Comparative Embryology. London, 1880.
3. Barrande, J. Système Silurien de la Bohème.
4. Boutan, L. Recherche sur la Fissurella. Archiv. de Zoöl. Exp. et Gen., 2e serie, T. III, suppl.
5. Bronn, H. S. Die Klassen und Ordnungen des Thierreichs. 1862–66.
6. Brooks, W. K. Embryology of the Fresh Water Mussels. Proc. Am. Assoc. Adv. Sc., 1875.
7. ——— The affinities of the Mollusca and Molluscoidea. Proc. Bost. Soc. Nat. Hist., Vol. XVIII, 1876.
8. ——— Development of Fresh Water Pulmonates. Johns Hopkins Univ., Biol. Lab. Studies, 1879.
9. ——— Development of the Oyster. Johns Hopkins Univ., Biol. Lab. Studies, 1, 1879–80.
10. Butschli, O. Entwickelungsgeschichtliche Beitrage. Zeitschr. für wissensch. Zool., B. XXIX, 1877.
11. Carpenter, W. B. On the Microscopical Structure of Shells. Reports, British Assoc. 1844, 1848.
12. Challenger Reports, Vol. XIII, Part XXXV, Report on the Lamellibranchiata, by E. A. Smith.
13. ——— Vol. XXVII, Part LXXIV. Anatomy of Deep Sea Mollusca, by Paul Pelseuer.
14. Cope, E. D. Origin of the Fittest. New York, 1887.
15. Coquand, H. Monographie du Genre Ostrea, Terrain Crétacé. 1869.
16. Dall, W. H. Report on the Mollusca (from the Reports of the Dredgings of the Blake Expedition). Bull. Mus. Comp. Zoöl. 1886. Dall; see also page 376.
17. Fischer, Paul. Manuel de Conchyliologie. Paris, 1881.
18. Forbes & Hanley. A History of British Mollusca. London, 1853.
19. Gould, A. A. Edited by W. G. Binney. Invertebrata of Massachusetts. Boston, 1870.
20. Hall, James. Natural History of New York, Palæontology. (See p. 381, note.)
21. Hatschek, B. Ueber Entwickelungsgeschichte der Teredo. Arbeiten aus dem Zool. Inst. Wien, Vol. III, 1881.
22. ——— Entwickelung der Trochophora von Eupomatus uncinatus. Arbeit. aus dem Zool. Inst. Wien. T. VI, 1886.
23. Horst, R. Contribution to our Knowledge of the Development of the Oyster, O. edulis. Bull. U. S. Fish Comm., Vol. II, 1882. Translation.
24. ——— The Development of the Oyster. Rep. U. S. Fish Comm. for 1884. Washington, 1886. Translation.
25. Huxley, T. H. Anatomy of Invertebrated Animals. New York, 1878.
26. ——— Oysters and the Oyster Question. Eng. Ill. Mag., Oct. and Nov., 1883.
27. Hyatt, Alpheus. Fossil Cephalopods of the Museum of Comparative Zoölogy, Embryology. Bull. Mus. Comp. Zoöl. Vol. III.
28. ——— Guides for Science Teaching. The Oyster, Clam and other Common Mollusks. Boston, 1880.
29. ——— Transformations of Planorbis at Steinheim, with Remarks on the Effects of Gravity upon the Forms of Shells and Animals. Proc. Am. Assoc. Adv. Sc., Vol. XXIX, 1880.
30. ——— Larval Theory of the Origin of Tissue. Proc. Bost. Soc. Nat. Hist., Vol. XXIII, 1884. See also Proc. Bost. Soc. Nat. Hist., Vol. X, 1866, pp. 302–303.
31. ——— Parallelism between the Individual and Order in Tetrabranchiate Cephalopods. Mem. Bost. Soc. Nat. Hist., Vol. I, 1867.
32. ——— The Evolution of the Cephalopoda. Science, Vol. III, Nos. 52–53, 1884.
33. ——— Values in Classification of the Stages of Growth and Decline, with Propositions for a new Nomenclature. Proc. Bost. Soc. Nat. Hist., Vol. XXIII, 1888.
34. ——— Genesis of the Arietidæ. Smithsonian Contributions to Knowledge. Washington, 1889.
35. Jackson, Robert T. Catching Fixed Forms of Animal Life on Transparent Media for Study. Science, Vol. XI, No. 275, 1888.
36. ——— The Development of the Oyster with Remarks on Allied Genera. Proc. Boston Soc. Nat. Hist., Vol. XXIII, 1888.
37. King, W. Monograph of the Permian Fossils of England. Palæontographical Society, 1850.
38. de Koninck, L. Animaux Fossiles Carbonifère, Belgium. 1842–44, Supplt.
39. Lacaze-Duthiers, H. Mémoire sur l'Organisation de l'Anomie. Ann. des Sc. Nat., IVe serie, T. II, 1854.
40. ——— Mémoire sur les Organes Genitaux des Acéphales Lamellibranches. Ann. des Sc. Nat., IVe serie, T. II, 1854.
41. ——— Mémoire sur le Développement des Branchies des Mollusques Acéphales Lamellibranches. Ann. des Sc. Nat., IVe serie, T. V, 1855.
42. ——— Histoire de l'Organisation et du Développement du Dentale. Ann. des Sc. Nat., IVe serie, T. VI, 1856. Continued in Vol. VII, 1857.
43. Lankester, E. Ray. Contributions to the Developmental History of the Mollusca. Phil. Trans. Vol. 165, Part 1, 1875.

44. Lankester, E. Ray. Mollusca. Encyclopædia Britannica, Ninth Edition, 1883.
45. Lea, Isaac. Observations on the Genus Unio. Vol. vi. Philadelphia. 1857.
46. Lovén, S. Bidrag till Kannedomen om utvecklingen af Mollusca Acephala Lamellibranchiata. Kongl. Vetenskaps Akademiens Handlinger. Stockholm, 1848. Translated into German in Archiv für Naturgeschichte, Vol. xv, i, 1849. A German reprint with plates was also published by Professor Lovén, in 1879.
47. Mitzukuri, K. Structure and Significance of some Aberrant Forms of Lamellibranchiate Gills. Quart. Journ. Mic. Sc., 1881. Reprinted in Johns Hopkins Biol. Lab. Studies, Vol. ii, 1883.
48. Morse, Edward S. On the Relations of Anomia. Proc. Bost. Soc. Nat. Hist., Vol. xv, 1870–71.
49. d'Orbigny, A. Paléontologie Francaise, T. 3 et T. 4. 1843–47.
50. Owen, Richard. Structure of the Shell in the Water Clam (*Spondylus varius*). Proc. Zool. Soc., Vol. v, 1837.
51. ——— On the Relative Positions to their Constructors of the Chambered Shells of Cephalopods. Proc. Zool. Soc., 1878.
52. Patten, W. The Embryology of Patella. Arbeit. Zool. Inst. Wien, B. vi, 1886.
53. ——— Eyes of Molluscs and Arthropods. Mittheilung d. Zool. Station zur Neapel, B. vi, 1885–6.
54. Peck, R. Holman. The Structure of the Lamellibranchiate Gill. Quart. Journ. Mic. Sc., 1877.
55. Pictet, F. J. Mollusques Fossiles de Genève.
56. Purdie, Alex. The Anatomy of the Common Mussels. Colonial Museum and Geol. Survey Dept., Wellington, New Zealand, 1887.
57. Rabl, C. Ueber die Entwickelungsgeschichte der Malermuschel. Jenaische Zeitschr., Vol. x, 1876.
58. Reeve, L. A. Conchologica Iconica, London.
59. Reichel, L. Ueber das Byssusorgan der Lamellibranchiaten. Zool. Anz., x, pp. 488–490.
60. Ryder, John A. An Account of Experiments in Oyster Culture and Observations Relating thereto. Rep. Maryland Fish Comm., 1881.
61. ——— The Microscopic Sexual Characteristics of the American, Portuguese and Common Edible Oyster of Europe Compared. Bull. U. S. Fish Comm., Vol. ii, 1882.
62. ——— On the Mode of Fixation of the Fry of the Oyster. Bull. U. S. Fish Comm., Vol. ii, 1882.
63. ——— On the Metamorphosis and Post-larval Stages of Development of the Oyster. Rep. U. S. Fish Comm , for 1882. Washington, 1884.
64. ——— A Sketch of the Life-history of the Oyster. Published in Dr. C. A White's Monograph (this list, No. 73).
65. ——— A Contribution to the Life-history of the Oyster, in "The Fisheries and Fishery Industry of the United States." Section 1, 1884, pp. 711–758.
66. ——— The Byssus of the Young of the Common Clam (*Mya arenaria*, L.). Am. Nat., Jan., 1889.
67. Sharp, Benjamin. Remarks on the Phylogeny of the Lamellibranchiata. Proc. Acad. Nat. Sc. Phil., 1888.
68. Schmidt, Ferdinand. Beitrag zur Kentniss der Postembryonalen Entwickelung der Najaden. Archiv für Naturgeschichte, li, B. i, 1885.
69. Sowerby, G. B. The Genera of Recent and Fossil Shells. London, 1821–26.
70. Stoliczka, Ferd. Cretaceous Pelecypoda of Southern India. Mem. Geol. Survey of India, 1871.
71. Tryon, George W., Jr. Structural and Systematic Conchology. Philadelphia, 1882.
72. Verrill, A. E. Invertebrate Animals of Vineyard Sound, etc. Rep. U. S. Fish. Comm. for 1871–72.
73. White, C. A. A Review of the Fossil Ostreidæ of North America. Rep. U. S. Geol. Survey, iv, 1884.
74. ——— On Mesozoic Fossils. Bull. U. S. Geol. Survey, 1884.
75. Whitfield, Robert P. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. Monogr. U. S. Geol. Survey, 1885.
76. Winslow, Francis. An Account of an Experiment in Artificially Fertilizing the Ova of the European Oyster. Rep. (—) Maryland Fish Comm., 1881.
77. Woodward, Henry. On the Structure of Camerated Shells. Pop. Sc. Rev., Vol. xi, April, 1872.
78. Woodward, S. P. Some Account of Barretia. The Geologist, Oct , 1882.
79. ——— Manual of the Mollusca. Fourth edition, by Ralph Tate, London, 1880.
80. Ziegler, H. Ernst. Die Entwicklung von *Cyclas cornea*, Lam. Zeitschr. für wissensch. Zool., Vol. xli, 1885.
81. Zittel, Karl A. Traité de Paléontologie. Translation by Dr. Charles Barrois, 1887.

XVIII. EXPLANATION OF PLATES.

The figures which illustrate this paper were drawn by Mr. J. H. Emerton or the author, with a few exceptions which are noted in the descriptions. All figures of microscopic material were either drawn directly from specimens with the aid of a Zeiss camera lucida, or were redrawn from camera drawings. The locality and date of collecting specimens are indicated in the description of figures excepting cases where those facts are given in the text. The magnification of figures and the principal references to the pages in the text where the figures are described or discussed are given as an aid to readers. Specimens figured in the plates or text, unless otherwise mentioned, are in the collection of the author. I have to thank Mr. Emerton for the pains he has taken in drawing the figures which largely illustrate this paper.

Besides the plates the following figures illustrate the text:

Figs. 1–8. *Orthoceras elegans* and *O. politum*, protoconch and apex of conch, by kindness of Professor Hyatt, ... p. 292.
Fig. 9. *Vermetus radicula*, adult, ... p. 294.
Figs. 10–18. *Ostrea edulis*, embryology, ... p. 295.
Figs. 19–22. " " " . . . . . p. 297.
Figs. 23–24. " " " . . . . . p. 299.
Fig. 25. " " " . . . . . p. 300.
Fig. 26. *Ostrea edulis*, prodissoconch, ... p. 312.
Figs. 27–29. *Ostrea edulis*, the spat, ... p. 314.
Figs. 30–31. *Perna ephippium*, young, ... p. 329.
Figs. 32–34. *Avicula sterna*, " . . . . . p. 330.
Fig. 35. *Cassianella decussata*, young, ... p. 332.
Fig. 36. *Vulsella rugosa*, young, ... p. 332.
Fig. 37. *Pecten irradians*, adult, ... p. 333.
Figs. 38–39. *Pecten magellanicus*, young, ... p. 348.
Fig. 40. *Pecten dislocatus*, shell structure of young, ... p. 348.
Figs. 41–42. *Anomia glabra*, adult, ... p. 354.
Fig. 43. *Anomia aculeata*, young, ... p. 361.
Fig. 44. *Unio cariosus*, glochidium, ... p. 367.
Fig. 45. *Margaritana undulata*, glochidium, ... p. 367.
Fig. 46. *Anodon cygnea*, glochidium, ... p. 367.
Fig. 47. *Anodon fluviatilis*, glochidium, ... p. 367.
Fig. 48. *Margaritana undulata*, young, ... p. 367.
Fig. 49. *Anodon fluviatilis*, young, ... p. 367.
Fig. 50. *Saxicava rugosa*, young, ... p. 372.
Fig. 51. *Rhombopteria mira*, adult, ... p. 380.
Fig. 52. *Malleus vulgaris* young, ... p. 383.
Fig. 53. *Pinna* sp. indet., young, ... p. 385.

Figs. 9, 37, 41 and 42 are electrotypes furnished by the kindness of Professor A. E. Verrill. Figs. 10 to 24 and 26 to 29 inclusive are electrotypes furnished by the kindness of Colonel MacDonald, United States Commissioner of Fisheries.

PLATE XXIII.

Fig. 1. Embryo of Patella in the morula or mesembryo stage. Fig. 1*a* is an optical section of a similar stage (after Patten). p. 291.

Fig. 2. Embryo of Paludina, gastrula, or metembryo stage: *g*, gastrula invagination; *m*, mesoderm cells (after Butschli). p. 291.

Figs. 3–4. Embryo of Patella, trochosphere or neoembryo stage viewed from the dorsal side. In the middle of this region the shell gland appears. Fig. 4 is a similar specimen viewed from the opposite or ventral side: *b*, blastopore (after Patten). pp. 288, 291.

Fig. 5. Embryo of *Pisidium pusilum*, typembryo stage: *s*, shell gland; *m*, mouth; *a*, anus; *f*, foot. p. 291.

Fig. 6. Embryo of Pleurobranchidium, typembryo stage: *s*, shell gland and beginning of shell; *v*, velum; *m*, mouth; *f*, foot. p. 291. (Figs. 5–6, after Lankester.)

Figs. 7–8. Glochidium of *Anodon fluviatilis*, from the gill cavities of the parent: *ad*, adductor muscle. This period is referable to the phylembryo stage. The shell has a straight hinge line, and the remarkable spurs, *sp*, on its ventral border. Fig. 8 is a different view of a similar specimen. Medford, November, 1888. × 75 diam. pp. 301, 312, 367.

Fig. 9. Developing *Modiolaria marmorata*, phylembryo stage: *ad*, anterior adductor muscle, which alone exists at this stage; *m*, mouth; *s*, shell, which has a straight hinge line.

Fig. 10. Developing *Cardium exignum*, phylembryo stage: *ad*, anterior adductor, which alone exists at this stage; *v*, velum; *m*, mouth; *i*, intestine; *a*, anus; *s*, shell, which has a straight hinge line.

Fig. 11. Developing *Montacuta ferruginosa*, phylembryo stage: *ad*, anterior adductor muscle, which alone exists at this stage; *v*, velum; *m*, mouth; *a*, anus; *f*, foot; *r*, *r*, *r*, retractor muscles of the velum; *s*, shell, which has a straight hinge line. (Figs. 9–11 after Lovén.) Figs. 9–11, pp. 280, 289, 291, 312, 375.

Fig. 12. Adult *Slava fibrosa*, showing a very marked change in form of the shell: *n*, nealogic stage; *e*, ephebolic stage (after Barrande), life size. pp. 293, 294.

Fig. 13. Developing Dentalium, phylembryo stage: *v*, velum; *s*, saddle-shaped shell. pp. 289, 291.

Fig. 14. Developing Dentalium, older than fig. 13. The completed periconch stage, comparable to the period of the completed protoconch in Gasteropods, etc.: *v*, velum; *s*, shell. (Figs. 13–14, after Lacaze-Duthiers.) pp. 289, 293.

Fig. 15. Young *Goniatites compressus*: *p*, ovoid protoconch, succeeded by true conch.[1] pp. 291, 311, 375.

[1]From Hyatt (27) after Sandberger.

Fig. 16. Young *Goniatites canaliculatus*, var. *gracilis*: *p*, globular protoconch, succeeded by true conch.[1] pp. 291, 311.

Fig. 17. Young Pteropod: *p*, ovoid protoconch (after Broun). p. 291.

Fig. 18. *Tentaculites acuarius*, Richter: *p*, protoconch (after Fischer). p. 291.

Fig. 19. Developing *Sycotopus canaliculatus*, completed protoconch stage: *h*, heart; *f*, foot; *v*, velum. The shell shows distinct lines of growth (after camera drawing by the author). × 24 diam., pp. 289, 291, 375.

Fig. 20. Developing *Sycotopus canaliculatus*, a period much later than the close of the protoconch stage yet still retaining a velum, *v*, which is enormously developed, and has a ramifying muscular system, shown in the figure: *f*, foot; *t*, tentacles; *e*, eyes and *m*, mouth. × 12 diam., p. 289. Figs. 19–20 from egg cases, Buzzards Bay, September, 1889 (after camera drawing by the author).

Fig. 21. Young *Crepidula fornicata*: *p*, spirally twisted protoconch, succeeded by the sub-conical nepionic growth. Buzzards Bay. × 24 diam., pp. 292, 293.

Fig. 22. *Crepidula fornicata*, a series of adult specimens growing on one another and with axes arranged in relation to currents. An oyster is attached to the base of the colony. Buzzards Bay. Life size, p. 354.

Fig. 23. *Crepidula fornicata*, much younger than fig. 21: *p*, the protoconch, which is sharply defined, is succeeded by the early nepionic growth. Nantucket, July, 1889. × 24 diam., pp. 292, 311.

Fig. 24. Young *Acmæa testudinalis* var. *alveus*. Interesting as showing instead of a protoconch, a plug-like cicatrix, *c*, formed where the protoconch dehisced. The cicatrix corresponds in form with the base of a typical protoconch. (Compare with fig. 23). × 87 diam., pp. 292, 293.

Figs. 7, 8, 17, 18, 23 and 24 drawn by the author; all others drawn by Mr. J. H. Emerton.

PLATE XXIV.

Fig. 1. Embryonic *Ostrea virginiana*, growing on a plate of glass from a drain-pipe trap. It is the completed prodissoconch stage and dimyarian: *a. ad*, anterior adductor muscle; *p. ad*, posterior adductor; *g*, gills, which consist of simple filamentous processes (compare with fig. 6); *v*, velum; *pl*, palps; *a*, anus; *m*, mantle border, which is broad and bears no tentacles. The shell is wholly prodissoconch growth, no spat growth having taken place, and is cemented to the glass by the ventral border of the left valve. The early straight hinge line similar to that of *Ostrea edulis*, fig. 25, p. 300, is lost and superseded by a curved one. × 120 diam., pp. 282, 300, 308, 378.

Fig. 2. Same specimen as fig. 1, viewed from the left side through the glass to which attached; lettering as in fig. 1.

Fig. 3. Ostrea, the same specimen as figs. 1 and 2, but three days older: *pl*, palps; *r*, rectum; *g*, gills, which at this stage are composed of filaments connected at the tips by cross connecting bars; *m*, mantle border, broad and not yet possessing marginal tentacles; *p*, the prodissoconch, which equals nearly half the entire height of the shell. Redrawn from camera drawing by the author. p. 304.

Fig. 4. *Ostrea virginiana*, young spat growing on glass: *ad*, adductor muscle; *pl*, palps. The body is permeated with liver follicles; *g*, gills. Three gill lamellæ are in view, *A*, *A'*, *B'*, for an understanding of which see fig. 8. In the early growth of the right, outer gill *B'*, no corresponding gill *B* exists on the left side; *st*, stomach; *int*, intestine; *a*, anus; *h*, heart; *v*, large blood vessel passing to mantle border; *c.d*, foramina through which afferent blood passes to heart; *m*, mantle border fringed with tentacles; *rm*, radial muscles which retract the mantle; *s*, a sinuosity in the upper right valve, exists at this point; the mantle is constantly retracted and all excurrent action takes place through this sinuosity as indicated by arrows; *p*, prodissoconch. Redrawn from camera drawing by the author. × 12 diam., pp. 305, 307.

Fig. 5. Gill plate from a young oyster of age of fig. 4, showing filaments joined by cross connecting bars. p. 305.

Figs. 6–12. Diagrams of gills of developing Ostrea and adult Perna, Anomia and Pecten. The filaments in all are lettered the same so as to show the relation of the several diagrams: *A*, direct filament of inner gill of left side; *a*, reflected border of same filament; *A'*, direct filament of inner gill of right side; *a'*, reflected border of same filament; *B*, direct filament of outer gill on left side; *b*, reflected border of same filament; *B'* direct filament of outer gill of right side; *b'*, reflected border of same filament.

Fig. 6. Gills of young *Ostrea virginiana*, age of figs. 1–2, this plate, pp. 301, 303.

Fig. 7. Gills of Ostrea, later stage, age of fig. 3, this plate, p. 304.

Fig. 8. Gills of Ostrea, still later stage, age of fig. 4, this plate, p. 305.

Fig. 9. Gills of adult Ostrea, see Pl. XXV, fig. 12, p. 306.

Fig. 10. Gills of adult *Perna ephippium*, see Pl. XXV, fig. 11 pp. 304, 326.

Fig. 11. Gills of adult *Anomia glabra*, p. 358.

Fig. 12. Gills of adult *Pecten irradians*, pp. 336, 341.

Figs. 13–16. *Ostrea edulis*, early phylembryonic stage of shell growth; 13, viewed from the right side; 14, from the ventral border; 15, from the left side; and 16, in end view. Compare with fig. 25, p. 300, an anatomical figure of about the same age. The shell has a straight hinge line and only a slight indication of umbos. From the gill chamber of the parent. × 120 diam., pp. 299, 312, 375.

Fig. 17. *Ostrea virginiana*, completed prodissoconch stage, viewed from the upper right side, the specimen being already cemented to an object of support: *r*, right valve; *l*, left valve. Compare with fig. 26, p. 312. × 87 diam., pp. 312, 378.

Fig. 18. A specimen slightly older than fig. 17, viewed from the anterior end: *l*, left valve; *r*, right valve; *s*, spat growth, which has begun along the margin of the prodissoconch valves. × 87 diam., pp. 312, 315.

Fig. 19. Young *Ostrea virginiana*. Tip of left valve from inside whorls of a dead Sycotopus, where it was preserved from

[1] From Hyatt (27) after Sandberger.

all eroding action: *p*, prodissoconch; *s*, spat growth; *l*, cartilage pit; *f*, flange-like extension of margin of the shell extending over the object of fixation; *b*, border of shell proper, exclusive of flange. × 87 diam., pp. 315, 329.

Fig. 20. Young *Ostrea virginiana*, growing on glass, viewed from right side, showing *p*. left and right valves of prodissoconch, and *s*, the first stages of spat growth. × 24 diam., p. 315.

Fig. 21. Same specimen as fig. 20, viewed from the left side through the glass to which attached: *p*, prodissoconch; *s*. spat growth. p. 315. Figures 17 to 21 are of specimens from Buzzards Bay.

Fig. 22. *Gryphæa arcuata*, umbos of shell showing flat area of early fixation in left valve and corresponding convex area of right. Specimen from Lower Lias; in Museum of Comparative Zoölogy. × 11 diam., p. 317.

Fig. 23. *Gryphæa calceola*, var. *nebrascensis*, showing a flat area of early attachment in this highly arcuate species and a prodissoconch, *p*. Jurassic of Wyoming, specimen No. 1881, U. S. National Museum. × 11 diam., pp. 313. 317.

Fig. 24. Same specimen as fig. 23, viewed from in front.

Figs. 3–4 and 22–24 drawn by Mr. J. H. Emerton; figs. 17–18 drawn by Mr. F. W. Cobb; all other figures drawn by the author.

PLATE XXV.

Fig. 1. Young *Ostrea virginiana*, growing on glass, viewed from the right side: *p*, left and right valves of prodissoconch; 1*s*, 2*s*, limits of first and second spat or nepionic stages.

Fig. 2. Same specimen as fig. 1, viewed from the left side through the glass to which attached: *p*, left valve of prodissoconch; 1*s*, 2*s*, limits of first and second spat or nepionic stages; *l*, margin of left valve, beyond which the right (upper) valve extends. Figs. 1 and 2, × 24 diam., p. 315.

Fig. 3 Young *Ostrea virginiana*, viewed from the hinge area: *p*, prodissoconch; *lv*, left valve; *rv*, right valve; *s*, early spat growth. The left valve has not yet flattened to the object of attachment. × 120 diam., p. 315.

Fig. 4. Young *Ostrea virginiana* viewed from right side, the specimen being attached to a shell: *p*, prodissoconch, succeeded by *s*, the early spat or nepionic growth. × 98 diam., pp. 311. 315

Fig. 5. Young *Ostrea virginiana* separated from a glass slide on which it had grown and viewed from right upper side: *p*, prodissoconch; 1*s*, 2*s*. 3*s*, 4*s*, four spat or nepionic stages of growth clearly indicated in this specimen; *si*. a sinuosity in the right valve where excurrent action takes place. Compare with left view of same specimen, fig. 6. × 8 diam., pp. 307, 316.

Fig. 6. Same specimen as fig. 5, but viewed from the left side, by which it was attached to the glass before removal. The left valve is seen to overhang the right on its free borders; at *si*. the excurrent sinuosity of the right valve is very noticeable in this figure, and four nepionic stages are marked in this valve as in the right valve. p. 316. Figs. 1–6, inclusive, are of specimens from Buzzards Bay.

Fig. 7. Young *Ostrea virginiana* from Provincetown, Massachusetts, showing nepionic or spat stages of growth of the right valve (1*s*, 2*s*, 3*s*, 4*s*, 5*s*). The first two stages were drawn from a younger specimen, as they were worn off in the specimen at hand. × ⅛ diam. p. 316.

Fig. 8. *Ostrea virginiana*. Two adult individuals fixed to the same object of attachment. The left hand specimen is growing in the normal position with the right valve uppermost, and the left valve lowermost. The right hand specimen is growing in a reversed position with the right valve lowermost, and the left valve, uppermost; in both the same relative form of the valves is maintained. Buzzards Bay. × ⅔ diam., pp. 316, 321.

Figs. 9–12. Revolution of the axes, showing the relations of the axes of the body to the shell in typical Pelecypods, and the serial mechanical relation of the same. Lettering in the figures: *ap. ax*, antero-posterior axis, drawn through the mouth and middle of the posterior adductor muscle; *h. ax*, hinge axis, the axis of motion of the valves; *a. ad*, anterior adductor muscle; *p. ad*, posterior adductor; *m*, mouth; *pl*. palps; *a*, anus; *g*. gills; *pd*, pedal muscles; *f*. foot; *b*, byssus; *h*, heart.

Fig. 9. *Mya arenaria*, p. 309.

Fig. 10. *Modiola plicatula*, p. 309.

Fig. 11. *Perna ephippium*, pp. 309, 329.

Fig. 12. *Ostrea virginiana*, pp. 305, 308, 327.

Fig. 8, drawn by the kindness of Mrs. J. W. Elliot; all other figures drawn by the author.

PLATE XXVI.

Fig. 1. *Spondylus hippuritarum*, having a highly modified, deep, attached valve and less modified free valve. European Cretaceous (after d'Orbigny). pp. 319. 323, 351.

Fig. 2. *Chamostrea albida*, showing an ostreaform, cemented valve and flatter free valve (after H. & A. Adams). p. 323.

Fig. 3. *Hinnites cortesi*, right valve, showing an early nealogic, regular pecteniform stage, possessing a byssal sinus, which is succeeded, when the shell becomes attached to a foreign body, by an irregular ostreaform growth, possessing no byssal sinus, and losing almost entirely the features characteristic of early stages. pp. 282, 293, 294, 324, 350 and 390.

Fig. 4. *Hinnites cortesi*, left valve, showing an early regular pecteniform shell, as does the right valve, fig. 3. When the

shell becomes attached, the left valve, acting in sympathy with the right, becomes somewhat irregular in growth; but is less modified than the right by the new condition of cemented fixation. Life size, p. 324. Both specimens from the European Tertiary, in the Museum of Comparative Zoölogy.

Fig. 5. *Malleria lobata*, showing adult oyster-like form and at the tip of umbos a regular Anodon-shaped shell preceding the attached stage (after H. & A. Adams). pp. 310, 324.

Figs. 6–7. *Malleria lobata*. Tips of the valves magnified to show the early stage, viewed from the dorsal and left side (after Brown). pp. 310, 324.

Fig. 8. *Caprinula boissyi*, having a deep, conical, rugose, attached valve and an arcuate, plain, free valve. European Cretaceous. pp. 282, 319, 323.

Fig. 9. *Monopleura marcida*, showing a highly modified attached valve and a normal free valve. American Cretaceous (after White (74), slightly modified). pp. 319, 323.

Fig. 10. *Caprotina semistriata*, showing a deep, rugose attached valve and shallow, plain, free valve. European Cretaceous. Compare with fig. 20, a young specimen of this species. pp. 319, 323.

Figs. 11–12. *Radiolites fleuriausa*, having a highly modified, cornucopia-shaped, attached valve, fig. 12, and a less modified flattish free valve, fig. 11. European Cretaceous, pp. 319, 324 (figs. 8 and 10–12, after d'Orbigny).

Fig. 13. *Ostrea virginiana*, section showing the deep, concave, cemented valve, and flat free valve: *l*, lacunæ in the sub-nacreous structure are filled with chalky lime: *ad*, adductor muscle, which makes a purple scar at its area of insertion in the valves. The black line indicates the position of the adductor at different periods of growth, and is very noticeable in the section, being marked by a continuous purple line. An instructive section to show action of adductor muscle, ligament, growth of shell and change of base of the muscle in successive growth. Buzzards Bay. Life size, p. 320.

Figs. 14–15. *Davidsonella rugosa*, sp. d'Orb., showing rugose, lower, attached valve (fig. 14) and a flat free valve (fig. 15), indicating that cementation in Brachiopods produces a similar result to that in Pelecypods. European Cretaceous (after d'Orbigny). p. 320.

Fig. 16. *Perna ephippium*, adult, pp. 327, 329, 383.

Fig. 17. *Perna isogonum*, p. 327.

Fig. 18. *Perna vespertilio*, p. 327.

Fig. 19. *Malleus albus*, adult. pp. 327, 383 (figs. 16–19 after Reeve, reduced).

Fig. 20. Young *Caprotina semistriata*, from the Cretaceous. The lines of growth are introduced according to judgment to render the parts clear, as the specimen is too much eroded to show them. Compare with the adult, fig. 10, this plate. Specimen No. 2902 in collections of the Museum of Comparative Zoölogy. × 24 diam. pp. 319, 385.

Fig. 20 drawn by the author; all others drawn by Mr. J. H. Emerton.

PLATE XXVII.

Fig. 1. Young *Perna ephippium*, viewed from left side, showing, *p*, prodissoconch and succeeding dissoconch growth. Compare with Pecten, Pl. XXVIII, fig. 9 and Avicula, fig. 32, p. 330. The form of the shell is strikingly different from the adult, Pl. XXVI, fig. 16. Specimen from Museum of Comparative Zoölogy. × 50 diam. (another view of this specimen, see Pl. XXVIII, fig. 11). pp. 328, 379, 383.

Fig. 2. Young *Perna ephippium*, viewed from the right side, showing, *p*, prodissoconch and succeeding dissoconch growth. The byssal notch originates at the close of the prodissoconch period in the initial stages of dissoconch growth. The figure shows the margin of left valve extending beyond the right in the byssal area and several threads of the byssus. Specimen from Boston Society of Natural History Collections. Cat. No. 2989. × 24 diam., p. 328.

Fig. 3. *Perna ephippium*, same specimen and view as fig. 2, showing the prodissoconch, *p*, and the early stages of growth of the right dissoconch valve. It is seen in figs. 2 and 3, that as in Pecten the left valve in early stages is larger than the right, and overhangs it at the umbos. × 87 diam., p. 328.

Fig. 4. Young *Spondylus asperrimus*, tip of right attached valve: *p*, prodissoconch; the succeeding early dissoconch growth is pecteniform with a deep byssal notch; as soon as attached the growth becomes irregular, the pecteniform shape and byssal notch being eradicated. Compare with Hinnites, Pl. XXVII, fig. 3. Specimen in Boston Society of Natural History, Cat. No. 8494. × 50 diam., pp. 351, 390.

Fig. 5. Young *Plicatula marginata*, viewed from the left side, showing a prodissoconch, *p*, and succeeding dissoconch growth. Specimen in Museum of Comparative Zoölogy. × 50 diam., pp. 325, 352, 392.

Fig. 6. Young *Lima elliptica*, showing, *p*, prodissoconch, succeeded by the dissoconch growth. Specimen in Smithsonian Institution. From drawing made when at that Museum. Magnified, pp. 353, 388.

Fig. 7. *Oxytoma inequivalvis*, Sow., umbonal region of right valve showing *p*, prodissoconch, succeeded by a dissoconch which has a byssal notch in its initial stages of growth, and a triangular cartilage pit. Compare with Pecten, several figs., Pl. XXVIII, and Avicula, fig. 33, p. 330. Specimen from the Middle Lias in the Museum of Comparative Zoölogy, Cat. No. 9222. × 50 diam., pp. 332, 382.

Fig. 8. *Chlamys islandica*, hinge area of same specimen as Pl. XXVIII, fig. 14, viewed from the right side, showing, *p*, prodissoconch, and the byssal notch originating in the initial stages of dissoconch growth. Compare with *Pecten irradians* Pl. XXVIII, figs. 10 and 13. The left valve is larger than the right. × 87 diam., p. 344.

Fig. 9. *Pecten irradians*. Umbonal view from left side of a similar specimen to that in Pl. XXVIII, fig. 10, more enlarged, showing *p*, prodissoconch, and the byssal notch originating at the close of the prodissoconch stage. × 87 diam., p. 342.

Figs. 1 and 6 drawn by the author; all others drawn by Mr. J. H. Emerton.

PLATE XXVIII.

Fig. 1. Young *Pecten irradians*, viewed from the left side: *ad*, adductor muscle; *g*, gills; *i*, intestine; *a*, anus; *h*, heart; *f*, foot; *p r*, posterior retractor of the foot; *m*, mantle border bearing eyes, *e;* and alternating tentacles, *t*. The shell bears a prodissoconch, *p*, and is of about the age of fig. 12, this plate. Redrawn from camera drawing by the author. × 40 diam., p. 333.

Fig. 2. *Pecten irradians*, older than any other young Pecten figured. Shows an active extensible foot; the mantle border bears a single eye in each plication of the shell and alternating with each eye two tentacles (tentacles are omitted in the right mantle lobe for the sake of clearness). Under the dorsal ear a special protrusion of the mantle border (pseudosiphon) exists, and at this point all excurrent flow takes place as indicated by the arrow. The shell shows no prodissoconch, but the smooth early nepionic stage is indicated. The plications are as in the adult, fig. 37, p. 333, in number and form. The hinge line is relatively long, and but slight ears are developed. × 16 diam., pp. 335, 345, 387.

Fig. 3. *Pecten irradians*, diagram of a gill filament of adult: *a*, direct border; *a'*, reflected border; *s*, septum connecting direct and reflected border of about every fifteenth filament; *bl*, blade commencing when septum diminishes. Compare with Pl. XXIV, fig. 12, p. 341.

Fig. 4. Pecten, diagrammatic section of adult, to show relations of mantle wall and tentacles: *s*, shell; *lig*, ligament; *ad*, adductor; *m*, mantle; *m w*, mantle wall; *e*, eye; *t*, marginal tentacles; *g t*, guard tentacles. p. 338.

Fig. 5. Faces of Pecten, seen in section and longitudinally. p. 340.

Fig. 6. Pecten, mantle border of fig. 1 enlarged, showing cup-shaped eyes alternating with single papillose tentacles; no mantle wall or guard tentacles are yet developed on the mantle border. pp. 335, 337.

Fig. 7. Young Pecten, diagram of foot. In forming the byssal attachment it may lay hold of a foreign object at its tip and at the point of the byssal cleft, arching up between those points as in the figure. p. 337.

Figs. 8, 8*a*. Pecten, diagram to illustrate the swimming. Arrows indicate the several currents of water ejected in swimming as described in the text. p. 339.

Fig. 9. Young *Pecten irradians*, viewed from left side: *p*, prodissoconch, succeeded by the early nepionic stage of the dissoconch. The form of the shell is distinct and differs from all later stages. Compare with Perna, Pl. XXVII, fig. 1, and Avicula, fig. 32, p. 330. × 50 diam., pp. 333, 342, 379, 387.

Fig. 10. Pecten, same specimen as fig. 9, but viewed from the right side. The byssal notch originates with the initial stages of dissoconch growth, it is deep, and has a marginal tooth. The left valve overhangs the right on its free border. Compare with Pl. XXVII, fig. 3, and Pl. XXIX, fig. 6. pp. 328, 342.

Fig. 11. *Perna ephippium*, same specimen as Pl. XXVII, fig. 1, viewed from umbonal region: *l v*, left valve; which is slightly larger than *r v*, the right valve. The umbos of the prodissoconch, *p*, are directed posteriorly. × 50 diam., p. 328.

Fig. 12. *Pecten irradians*, older than figs. 9–10, viewed from the left side: *p*, prodissoconch, succeeded by smooth early nepionic growth which gives place to a plicated later growth. The hinge line is proportionately longer than in earlier stages, figs. 9–10, and is also relatively longer than in the adult, fig. 37, p. 333. Very slight indications of ears exist at this stage. × 40 diam., pp. 345, 387.

Fig. 13. Pecten, same specimen as fig. 12, viewed from the right side. Description of shell as in fig. 12. A deep byssal notch exists in this valve, originating at the close of the prodissoconch period. Four teeth exist on the border of the notch instead of one as in fig. 10. At this age the left valve has ceased to be produced beyond the border of the right on on its free margins, as in fig. 10. The shell as viewed from both sides differs markedly from earlier and later stages in form. p. 345.

All the specimens of *Pecten irradians* figured were collected at Buzzards Bay, August, 1888.

Fig. 14. Young *Chlamys islandica*, viewed from left side, showing, *p*, prodissoconch, and a smooth early nepionic growth, succeeded by a plicated later growth. The plications are like those of the adult and mark a stage by their introduction. The hinge line is longer relatively to the width of the shell at this stage than in the adult as noted in *Pecten irradians*, and has slightly developed ears. Specimen No. 27294, Smithsonian Institution Catalogue. × 23 diam., pp. 349 and 388. An enlarged umbonal view of this specimen seen from the right side, *vide* Pl. XXVII, fig. 8.

Figs. 3–8 drawn by the author; all others drawn by Mr. J. H. Emerton.

PLATE XXIX.

Fig. 1. Young *Anomia glabra*, growing on glass, viewed from the left side: *ad*, adductor muscle; *p r*, posterior retractor and *a r*, anterior retractor muscles of the foot; *f*, foot; *pl*, palps; *a*, anus; *b*, body permeated with liver follicles; *g*, gills. Two gill lamellæ are seen from this side, *A* and *b* (compare with diagram, Pl. XXIV, fig. 11); *s*, sheath supporting gills; *h*, heart; *v*, *v*, blood vessels; *m*, mantle border; *p*, prodissoconch. p. 355.

Fig. 2. *Anomia*, same specimen as fig. 1, viewed from the right side through the glass to which attached: *ad*, adductor muscle; *a r*, anterior retractor muscle of the foot, attached to the left upper valve, but seen through the glass; *bs*, calcifying byssal tip composed of separate discs of lime which unite to form parallel lines, as shown in the figure; *f*, foot; *pl*, palps, showing slightly in this view; *g*, gills of which three lamellæ, *a*, *A'*, *b'*, are visible from this side (compare with Pl. XXIV, fig. 11); *s*, sheath which supports the gills; *h*, heart, a ventricle and auricle are visible from this side; *a*, anus; *c*, cæcum, highly produced; *m*, mantle border; *rv*, border of right valve which by a sinuosity encloses the byssus; *lv*, border of left valve. Figs. 1 and 2 magnified about 20 diam. Redrawn from camera drawings by the author. p. 355.

Fig. 3. Diagrammatic cross-section of fig. 1, to show action of the muscles; lettering as in fig. 1. p. 355.

Fig. 4. *Anomia glabra*, very young, viewed from the left side: *p*, prodissoconch, which is on the border of the valve, not yet being enclosed by the dissoconch growth. × 50 diam., p. 359.

Fig. 5. Young *Anomia glabra*, viewed from the left side: *p*, the prodissoconch, is not yet surrounded by dissoconch growth. Compare with figs. 4 and 8. The dissoconch is sub-oval and an extensible foot, *f*, exists. × 50 diam., pp. 355, 389.

Fig. 6. Anomia, same specimen as fig. 5, viewed from right side: *p*, the prodissoconch, shows indications of a byssal sinus in the lines of growth. The dissoconch is extremely thin, surrounds the byssal notch and anteriorly has grown around the prodissoconch covering its umbo. The method of growth is indicated by the lines of growth. pp. 359, 388. Compare with Pecten, Pl. XXVIII, fig. 10.

Fig. 7. Young *Anomia glabra*, umbonal region of right valve: *p*, the prodissoconch, shows indications of a byssal notch which is accentuated in the succeeding dissoconch growth; the latter finally grows around the byssus so as to enclose it. Compare with fig. 6, this plate, also with Pl. XXVII, fig. 3, and Pl. XXVIII, fig. 10. × 50 diam., p. 360.

Fig. 8. Anomia, tip of valve, older than figs. 4 and 5 and in the same view. The dissoconch growth has now enclosed the prodissoconch, *p*, and the borders of the opposing sides form a marked area by their ingrowth at the umbo. × 50 diam., pp. 359, 389. Specimens of Anomiæ, figs. 1–8, were collected at Buzzards Bay, August, 1888.

Fig. 9. *Mytilus edulis*, very young: *p*, the prodissoconch, succeeded by early nepionic growth. Beach Bluff, Mass. × 50 diam., p. 363.

Fig. 10. *Mytilus edulis*, older than fig. 9; *p*, prodissoconch, succeeded by nepionic growth. Nantucket. × 47 diam.

Fig. 11. Young *Modiola hamatus*: *p*, prodissoconch, succeeded by a smooth nepionic stage. Later, the smooth nepionic stage is succeeded by the plicated growth typical of the species as shown in Pl. XXX, fig. 1. Specimen on oyster shells from Baltimore, collected at Martha's Vineyard. × 50 diam., p. 364.

Figs. 3, 5, 6, 9, 10 and 11 drawn by the author; all others by Mr. J. H. Emerton.

PLATE XXX.

Fig. 1. *Modiola hamatus*, older than Pl. XXIX, fig. 11: *p*, prodissoconch, succeeded by an early plain nepionic stage, which is again succeeded by a plicated later stage. Attached to a cluster of Pernas in Museum of Comparative Zoölogy. × 50 diam., p. 364.

Fig. 2. *Argina pexata*, very young, showing a prodissoconch, *p*, and succeeding dissoconch growth. Buzzards Bay, September, 1888. × 87 diam., p. 364.

Fig. 3. *Crenella decussata*: *p*, prodissoconch, succeeded by the early dissoconch growth. Specimen from Smithsonian Institution. × 23 diam., p. 364.

Fig. 4. *Sphærium securis*: embryo from gills of the parent. The whole shell of this specimen represents the prodissoconch period: *a. ad*, anterior adductor; *p. ad*, posterior adductor; *g*, gill filaments; *pl*. palps; *f*, foot; *ot*, otocyst; *si*, siphon. Medford, Mass., Nov. 1888. × about 60 diam., p. 369.

Fig. 5. *Sphærium securis*, a little older than fig. 4, viewed from left side: *p*, prodissoconch, succeeded by early dissoconch growth. × about 25 diam., p. 369.

Fig. 5*a*. *Sphærium securis*, a little older than figure 5, viewed from right side: *p*, prodissoconch. × 8 diam., p. 370.

Fig. 6. Young *Petricola pholadiformis*, showing *p*, prodissoconch and succeeding nepionic stage which is strikingly different from later stages: *f*, foot; *m*, mantle border; *si*, siphons, both with simple, unbranched tentacles. × 47 diam., p. 370.

Fig. 7. *Petricola pholadiformis*, older than fig. 6, shows early nepionic smooth stage succeeded by the later characteristic plicated and elongate features typical of the adult. × 8 diam., p. 371. Figs. 6–7, of specimens from Nantucket, July, 1889.

Fig. 8. *Petricola*, tip of branchial siphon of a specimen of about the age of fig. 7, showing the arborescently branching tentacles which surround the orifice. × 19 diam., p. 371.

Fig. 9. Young *Venus mercenaria*: *p*, prodissoconch, succeeded by early dissoconch growth. × 87 diam., p. 371.

Fig. 10. *Venus mercenaria*, an older specimen than fig. 9, showing a prodissoconch *p*, and succeeding nepionic growth. × 40 diam., p. 371. Figs. 9–10 from Buzzards Bay.

Fig. 11. *Scrobicularia tennis*: *p*, prodissoconch succeeded by early dissoconch growth. The prodissoconch is not so sharply defined as in many genera, because the early dissoconch is not characterized by markedly differing features. Specimen from Smithsonian Institution. × 50 diam., p. 372.

Fig. 12. *Mya arenaria*, very young: *p*, prodissoconch, and well defined succeeding dissoconch. Buzzards Bay, 1888. × 87 diam., p. 374.

Fig. 13. *Mya arenaria*, older than fig. 12: a prodissoconch, *p*, less clearly defined than when younger, exists at the umbos. The dissoconch growth has acquired characteristics of the genus in form. A large active foot exists. The siphon consists of an extensible excurrent and a short non-extensible incurrent tube. Buzzards Bay. × 20 diam., p. 372.

Fig. 14. Siphon of a young clam older than fig. 13. The massive siphon is fringed with tentacles. The incurrent tube is also bordered by tentacles, but the excurrent tube bears none; it is thin walled and retractile: *s*, border of shell from which the siphon extrudes. Chelsea Beach. × 10 diam., p. 373.

Figs. 4 to 8 inclusive, and fig. 14 drawn by the author; all others drawn by Mr. J. H. Emerton.

IX. New Types of Cockroaches from the Carboniferous Deposits of the United States.

By Samuel H. Scudder.

Read May 7, 1890.

Since the publication of my revision of the carboniferous cockroaches of the world, a very considerable number of new forms have been described from the Old World and a good many additional kinds have been found in our own country. A few of these from the Richmond, Ohio, coal fields have been described by me, and a very large number more are in my hands awaiting investigation. The forms herewith described (for the first time in full) have been awaiting an opportunity for illustration before final publication, and extend considerably our knowledge of the ancient fauna, several of the species showing much more than the upper wings, upon which we have heretofore mainly depended. The larger part of them come from Mazon Creek, Ill.

MYLACRIDAE Scudder.

As there are two generic forms to add to the three published in my paper on Palaeozoic cockroaches, I add a new table of the genera of this family.

TABLE OF THE GENERA OF MYLACRIDAE.

All the branches of the mediastinal vein arising close to the base of the wing.
- Mediastinal and scapular areas together occupying less than half the wing.
  - Scapular area larger than the mediastinal . . . . . **Mylacris.**
  - Scapular area smaller than the mediastinal . . . . . **Promylacris.**
- Mediastinal and scapular areas together occupying half or more than half the wing.
  - Wings broad; externomedian area expanding apically . . . . . **Paromylacris.**
  - Wings narrow; externomedian area small and compressed, scarcely expanding apically . **Lithomylacris.**

A number of the apical branches of the mediastinal vein arising beyond the base of the wing and scarcely partaking of the radiate arrangement of the others. . . . . **Necymylacris**

Mylacris mansfieldii.

Mylacris mansfieldii Scudd., Mem. Bost. Soc. Nat. Hist., III, 47 (1879).

A fragmentary and small specimen of this species, affording some points in addition

to the original specimen, has been sent me by Mr. W. F. E. Gurley. It is incomplete and the best face is broken into several fragments, but it shows the greater part of the costal margin with the outer tip of the wing. Though the wing tapers apically, this tip is not at all pointed, as was supposed from the original imperfect specimen, but well rounded, and the costal margin is pretty regularly and gently rounded but a little flattened beyond the basal two-fifths of the wing, where there is a slight change in the curve, due to this flattening. As in the original, two or three of the mediastinal rays are forked near their origin, and the mediastinal area appears to extend a very little further than in the original. What can be seen of the other areas (the scapular vein is nearly complete, but only a little of the others) agrees tolerably well with those of the original specimen, except that the externomedian vein certainly begins to fork at an earlier part of its course, namely at about the same point as the scapular vein. The wing is preserved a little further toward the base than the original, but only imperfectly, so that little more can be learned from it. None of the anal veins appear.

Length of fragment, 17 mm.; probable length of wing, 21 mm.

The specimen was found at Petty's Ford on the Little Vermilion river, four miles east of Georgetown, Vermilion Co., Illinois, in the same deposits that furnished *Propteticus infernus* Scudd.

Promylacris (πρὸ, μυλακρίς).

Promylacris Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 34.

Allied to Paromylacris, remarkable like it for its strong convexity, and its stoutness of form, although surpassed by Paromylacris in both features; the frontal shield is about twice as broad as long, sometimes much less than that, and the wings are considerably less than half as long again as their united breadth.

The mediastinal vein, though large and abundantly supplied with veins, terminates at about the middle of the wing; most of the branches fork. The scapular and externomedian veins together occupy the greater part of the wing, the latter terminating below the tip of the wing, but in the different species known they are of varying importance, sometimes the externomedian, at others the scapular, having the predominance; in all, the externomedian branches are long and nearly straight. The internomedian area is narrow, though deep, its veins few and faint. The anal furrow which terminates only a little before the middle of the wing is very deeply impressed and the anal area strongly convex and raised, its veins regular, simple or forked, frequent, and strongly curved.

Indications of legs in one species show that the femora were about as long as half the width of the tegmina, and about as stout as in the modern species of Periplaneta.

This genus is closely allied to Paromylacris, but differs from it strikingly in the much smaller development of the mediastinal area and the course of the scapular vein, which runs through the middle of the wing in Paromylacris but here considerably above it. The costal margin of the wings is much more convex here than in Paromylacris, the pronotal shield not so broad in proportion to its length, though this is variable, and the whole insect not so stout nor so arched.

Three species are known which may be separated as follows:

TABLE OF THE SPECIES OF PROMYLACRIS.

Prothorax distinctly twice as broad as long. Scapular vein much more important than the externomedian
1. **P. testudo.**

Prothorax distinctly less than twice as broad as long. Scapular vein not more important than the externomedian.
Prothorax more than half as broad again as long. Scapular vein far less important than the externomedian; anal veins simple . . . . . 2. **P. ovalis.**
Prothorax less than half as broad again as long. Scapular vein not far less important than the externomedian; anal veins mostly forked . . . . . 3. **P. rigida.**

1. **Promylacris testudo** sp. nov.

Pl. 32, fig. 6.

A single excellently preserved specimen showing both obverse and reverse, slightly broken on one side. The form of the body with closed wings is slightly more elongate than in *P. ovalis* and it is a smaller species.

The front wings have a strongly developed well rounded humeral lobe; the costal margin is strongly and regularly convex, while the inner margin is nearly straight, and the apex, so far as can be told, well rounded and not at all produced. The mediastinal area, which is very broad at base, rapidly narrows and terminates at some distance before the middle of the wing and before the anal furrow; the main vein is sinuous in its course, and several of the radiating branches arise from the main stem and nearly all are forked near the margin. The scapular vein, strongly arcuate at the base, is nearly straight but apically arcuate in the opposite sense, running in the middle subparallel to the costal margin, terminating just before the tip of the wing; half a dozen more or less forked branches originate from it mostly in the middle third of the wing, neighboring ones sometimes amalgamated at their bases into a bunch. The externomedian branches occupy all but the upper portion of the tip of the wing, but they are not numerous, though the earliest originate as far or nearly as far as the scapular branches. The internomedian area apparently occupies about half the space from the anal furrow to the tip of the wing, but the veins are few and obscure. The anal furrow is very deeply impressed, the anal area being strongly vaulted, its veins delicate, numerous, straight and parallel; the furrow terminates a little beyond the middle of the wing.

The whole body is considerably arched but the outer fourth of the costal region from the scapular vein to the margin is flattened, a flattening which is shared in no way by the transverse pronotum; the latter is slightly more than twice as broad as long with well arched, slightly appressed front, pronounced though rounded posterior lateral angles, scarcely convex hind margin, and minutely marginate edge; a slight median furrow is indicated, besides two anteriorly converging but distant straight and faint depressions of the surface, and a scarcely perceptible similar V-shaped central impression.

Length of whole body, 23 mm.; of pronotum, 4.75 mm.; width of same, 10.5 mm.; length of wing, 19 mm.; breadth, 8 mm.; breadth of closed wings, 14 mm.

The single specimen known comes from Mazon Creek, Ill., and was received for examination from Dr. J. S. Newberry. It is preserved in the Columbia School of Mines.

2. Promylacris ovalis.

Pl. 31, figs. 1–4.

Promylacris ovale Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 34–45.

This species is represented by a single specimen and its reverse, in a nodule preserving well the front half or more of the body.

The wings have all the tip removed, but the curve of the costal margin is so strong that we may believe only a little less than a third to be gone. This would give to the whole body a rather short obovate form. The front wings have a strongly developed humeral lobe, and a costal margin of considerable convexity; the inner margin appears to be straight but is ill defined. The mediastinal vein originates at the middle of the base of the wing, and after the basal curve the innermost vein runs in a straight course to near the end of the fragment, or to what is apparently near the middle of the wing; most of the branches dichotomize. The scapular vein runs, beyond the base, in a nearly straight course constantly approaching the margin and terminates apparently at the middle of the apical half of the wing; it has three principal branches each of which has several superior branchlets. The externomedian vein is far more important, occupying with numerous branches the entire apex of the wing; the principal branches are three, all of which originate near together far toward the base and dichotomize beyond. The internomedian area is unusually small, reaching apparently not so far toward the tip as the scapular. The anal area is considerably domed, the furrow very deep, considerably curved and ending only a little beyond the basal third of the wing; the veins are numerous, simple, parallel, curved.

Besides the wings, the prothoracic shield and the legs may be seen; the former is regularly arched, about a fourth as high as broad, and twice as broad as long; the latter are seen but vaguely as discolorations through the wings, but closely resemble those of modern cockroaches; whether they are spined or not cannot be said.

Length of fragment of wing, 20 mm.; estimated entire length, 29 mm.; breadth of same, 12 mm.; length of prothoracic shield, 8.5 mm.; breadth of same, 15.5 mm.; length of hind femora (partly estimated), 7 mm.; breadth of same, 1.5 mm.

The single specimen comes from Mazon Creek, Ill., and was sent to me by Mr. W. F. E. Gurley of Danville, Ill.

3. Promylacris rigida sp. nov.

Pl. 31, fig. 6.

A single specimen of which the anterior half is well preserved, including most of the prothoracic shield; but the apical half of the tegmina is broken away, revealing the apical parts of the hind wings somewhat displaced. It is of about the size of *P. ovalis* and resembles it more than it does the other species, but has its prothoracic shield much narrower in proportion to its length, being distinctly less than half as broad again as long, the front margin distinctly though bluntly angulated in the middle, smooth throughout, very gently and uniformly arched and overlapping the wings posteriorly.

The fore wings have a well developed angulate humeral lobe, so that the curve of the prothorax is hardly interrupted in passing to the wing; the costal margin is regularly but not strongly convex, much less convex than in either of the other species, so far as it can be traced. The mediastinal area is triangular, broad at base and rapidly narrowing, terminating at the middle of the wing and slightly beyond the anal furrow; the radiating veins are almost perfectly straight and only the outer ones fork and then but singly and deeply. The scapular vein is almost rigidly straight, stiffly forking beyond its basal fourth, the upper branch again dividing in a similar way near its base, and altogether much resembling a continuation of the mediastinal vein, and covering on the margin only the proximal half of the outer half of the wing. The externomedian vein is similarly rigid in its upper half, but in its lower shows the proximity of the more arcuate internomedian; it divides close to the base into two branches, the upper of which mimics the scapular, forks once before the middle of the wing and probably again beyond, while the lower with a downward curve, scarcely perceptible in the part preserved but no doubt more pronounced beyond, forks a little earlier than the upper branch, each fork again dividing at about the middle of the wing; this vein evidently holds the tip of the wing in its grasp. The internomedian vein, feeble in structure, is gracefully arcuate, but otherwise closely resembles the preceding; for it divides in two branches close to the base, the upper forking just before the middle, the lower sending out two or three arcuate simple or forked veins to the inner margin. The anal furrow is sharp and deep, considerably curved, terminates considerably before the middle of the wing, the anal area well domed, with numerous, parallel, mostly simple and deeply forked veins, the outer ones more arcuate than the others and simple.

The hind wings are exposed apically but not enough to show much of the structure of the wing for want of the vein-attachments. It would appear, however, as if the scapular area were very broad and nearly uniform in the distal half of the wing with relatively few, oblique, moderately distant, straight branches; that the externomedian was not greatly different from what appears on the fore wing; and that the rounded apex was somewhat pointed.

Length of entire fragment as misplaced, 43 mm.; probable length of creature, 37 mm.; length of prothorax, 12.5 mm.; breadth of same, 16.5 mm.; probable length of fore wing, 28 mm.; apparent breadth of same, 16.5 mm.

One specimen from Mazon Creek, received from Mr. R. D. Lacoe under the number 2086ab.

Paromylacris (*πάρος*, *μυλακρίς*)

Paromylacris Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 35.

An exceedingly broad, rounded, and well arched cockroach, in which the pronotal shield is broadly rounded in front and slightly convex behind, broad in proportion to its length, and the wings not half so long again as their united breadth.

The wings in the only specimens known are imperfectly preserved, but sufficiently to show that the species cannot fall into any described genus of Mylacridae. The mediastinal vein of the upper wing consists of at least seven or eight principal branches originating near the middle of the base of the wing, several of them forking close to the base

and one or two dividing simply beyond the middle; all of them are straight or very slightly curved, the outermost extending far toward the tip of the wing, so as to give this area an unusual preponderance; it occupies indeed about one-fourth of the wing. The scapular vein runs subparallel to the costal margin in a straight course through the middle of the wing to its extreme tip, so that this area and the mediastinal together occupy fully one-half the wing, dividing it between them by a straight and very oblique line; this vein emits four or more long straight branches parallel to the outer mediastinal branches, all of them, with the possible exception of an apical, forking once at or beyond their middle. The externomedian vein begins to fork at about the middle of the wing with dichotomizing branches which, however, do not separate widely and occupy on the margin only the lower half of the broad apex; these branches cannot be called either superior or inferior, as the forks part equally in opposite directions. On the inner margin the internomedian area occupies less space than the anal, and is filled with a number of closely approximate parallel veins scarcely curved and directed obliquely in an opposite sense to those of the mediastinal area. The anal furrow is deeply impressed, broadly curved, and strikes the middle of the inner margin.

The wings are peculiar for their extreme breadth and rounded outline; the costal border is not greatly curved so that the tip of the wing is unusually blunt; they are broadest in the middle, and scarcely twice as long as broad.

Besides the upper wings and the unusually broad pronotal shield, some few unimportant veins of the hind wings occur, but too insignificant to have any special value.

The genus differs from Mylacris, with which it best agrees, in the form of the wing, which does not taper apically but only has the tip rounded off, in the slight obliquity and gentle curve of the anal furrow, in which it resembles Lithomylacris, and very strikingly in the great extent and apical extension of the mediastinal area; in this latter point it recalls somewhat the features of Necymylacris, but only superficially, as the veins all originate and diverge from the base of the wing and show no tendency to simulate the Blattinariae. In its great breadth it is at once distinguishable from Lithomylacris, from which it further differs in the lesser proportionate breadth of the combined mediastinal and scapular areas. Its position in the system is indicated in the table of genera given above.

Two species are known.

Paromylacris rotunda.

Pl. 32, figs. 1, 2.

Paromylacris rotundum Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 35.

The front wing is obovate, scarcely narrower at tip than at base, barely twice as long as broad, the costal border gently and regularly convex, the apex broadly and regularly rounded; transversely also the wings are arched. The base of the wing is injured, but the veins apparently originate in the very middle of the base, with little if any upward curve at starting. The mediastinal area is very large, occupying half of the width of the wing at base, and extending to the middle of the distal third of the wing apically; the numerous veins of this area are traceable to about eight basal shoots, which radiate considerably and not unfrequently fork singly (one is doubly forked), but there is a con-

siderable humeral space altogether devoid of any trace of veins; the humeral angle itself is very prominent, nearly rectangular, the extreme angle rounded. The scapular vein, in the part where it is preserved, which does not include the basal third, is perfectly straight, running through the middle of the wing but slightly nearer the costal than the inner border and slightly oblique, being a very little lower apically, where it terminates at the middle of the tip, than at base; it begins to branch at the end of the basal fourth of the wing, and emits four or perhaps five straight superior branches, the third before the middle of the wing and the fourth at some distance beyond, or at the middle of the outer half of the wing; the third branch consequently not only emits an inferior offshoot, but the latter is again forked to fill the space between the third and fourth scapular branches. The externomedian vein is exactly parallel to and equidistant from the scapular, excepting in the terminal fourth of the wing, where it slightly approaches it; it first divides a little before the middle of the wing, and both these branches, but especially the lower, dichotomize to some extent, but do not diverge widely, so that the inner limits of the externomedian area are not further removed from the tip than those of the scapular. The internomedian vein is obscure, but its branches are scarcely less longitudinal than those of the mediastinal vein and are as closely crowded as those of the externomedian. The anal furrow strikes the middle of the inner margin, but the anal veins are not preserved.

The species is a large one, the largest of this group of Palaeoblattariae excepting *Necymylacris heros*, the length of the wing being 29.5 mm. and its breadth 15 mm., or about as 2 : 1. The specimen is composed of a pronotal shield and the two upper wings, besides a cluster of veins of one of the lower wings which, however, are of no importance; the pronotal shield is nearly perfect, and the wings are related to it in the position of repose, showing the whole animal to have been 38 mm. long from the front of the pronotum to the tip of the fore wings, and 22 mm. in breadth across the middle of the basal half of the wings. A large part of the anterior base of both wings is obscured by poor preservation, the outer half or more of the right wing is wanting, and the left wing lacks all the anal veins and a piece is broken from the apex. The wings may be seen to be transversely wrinkled between some of the veins, but as a general thing they appear to be as smooth as the pronotum, and as if of the same opacity.

The body is strongly arched, the central portion of the pronotal shield being elevated about 4.5 mm. above the margins and regularly rounded in every direction. Fig. 1 shows a cross section taken slightly behind the middle of the pronotum. The pronotum is very large and broad, being 20 mm. broad and about 10 mm. long, the front very broadly rounded, the sides tapering and convex, the hind margin apparently (from the little that can be seen of it) nearly straight but regularly convex; it is rather delicately margined around its lateral and front borders, as shown in both figures. The surface of the pronotum is entirely smooth, excepting in a rather narrow, rather small, subtriangular, central field, its broken apex at the front margin; this area is slightly roughened or scabrous and shows slight signs of a median, longitudinal, very blunt carina which does not appear in the figure.

The specimen was submitted to me by Mr. R. D. Lacoe, in whose collection it bears the number 2026. Both obverse and reverse are preserved. It occurs in an ironstone

nodule 60 x 45 mm. in size, found in the carboniferous beds of Mazon Creek, Grundy Co., Illinois.

Paromylacris ampla sp. nov.

Pl. 31, fig. 7.

The single specimen known is of large size and tolerably well preserved, showing the prothorax (imperfectly), most of the fore wings, and an unimportant part of the hind wings. The body is not so strongly vaulted as in the preceding species, but is considerably more arched than most modern cockroaches. The prothorax is not wholly exposed, being partly still imbedded in the rock (upon the right side of the figure), but it is apparently not quite twice as broad as long and so differs conspicuously from the other species; a triangular space in the posterior middle of the disk is flattened and more or less rugose, while the rest is smooth; there is no sign of margination. In the wings, however, the vaulted area terminates just before the costal edge, leaving a slight horizontal marginal shelf free of arcuation.

The fore wings are a little more than twice as long as broad, the costal area well but not strongly arcuate with a decided humeral angle. The mediastinal area is large, occupying just about one-fourth of the wing, triangular, broad at base, tapering to the tip which is well beyond the middle of the wing; the proximal veins of this area are single, the middle ones deeply and widely forked and the distal third or more is occupied by a compoundly forked vein, all of these radiating with a faint arcuation. The scapular vein is sharply curved at base and beyond runs nearly straight through the middle of the wing and must terminate at or even below the tip; its branches, four or five in number, are either singly forked somewhat beyond their middle or are simple and all are subparallel to the innermost course of the mediastinal vein. The externomedian and internomedian veins have little space wherein to develop and each is simple and single in its basal half and nearly straight except for the necessary basal curve; probably in their outer half they occupy about equal space. The anal furrow is very deep and sharp, and the anal area strongly vaulted, especially in the neighborhood of the former, which is very strongly rounded, nearly bent at base and beyond this at first straight, then gently arcuate, terminating apparently well beyond the middle of the wing; the anal veins, overlooked by the artist, are very numerous, parallel, arcuate, simple, nearly twice as close as the veins of the wing generally.

Parts of the hind wing are also seen beyond the broken fore wings, but show only a multitude of nearly parallel and straight, simple or forked veins.

This species differs from the preceding in its more oval contour, tapering much more at both ends, the less vaulted form, the longer and narrower thorax, and the simpler and weaker construction of the externo- and internomedian veins.

Length of fragment, the hind wing a little thrust beyond its natural position, 45 mm.; probable length, 42 mm.; length of prothorax, 12 mm.; breadth of same, at least 21 mm.; length of fore wing, 31 mm.; breadth of same, 14 mm.

One specimen, Mazon Creek, Ill. Received from Mr. R. D. Lacoe under the number 2088ab.

Lithomylacris pauperata sp. nov.

Pl. 32, fig. 5.

The single specimen represents a fragment of a front wing unfortunately very imperfect, but still sufficiently preserved to show that it is a Lithomylacris, allied to *L. pennsylvanica*, but much larger than it, and certainly distinct from any known species. Not one of the borders is preserved, although in several places the veins are evidently perfect to their tips.

Only one or two of the mediastinal veins can be seen, the outer one long and straight and minutely forked at the tip, with no other offshoots, unless it be at the base, showing the insect to belong to the Mylacridae; within this the forked extremity of another parallel vein can be seen. The scapular vein is perfectly straight as far as what is probably the centre of the wing, and in this basal portion runs down the middle of the wing, thus proving its proper reference to this genus; beyond this it curves very gently and slightly upward; in the fragment it emits four branches, the basal two close together, the others far apart, and the last at the very tip of the piece; the first is simple, the second and third simply forked at no great distance from their origin, and all run in a longitudinally oblique direction, subparallel to the mediastinal vein. The externomedian vein is exactly parallel to the scapular and hardly more distant from it than two adjoining scapular branches from each other; it divides far toward the base, apparently opposite the middle of the anal furrow and just beyond the second branch of the scapular vein, each of its branches again forking opposite the extremity of the anal furrow, and the uppermost branchlet again before the end of the fragment is reached. The internomedian vein is entirely composed of very faintly impressed lines, emits two parallel arcuate branches close together a little nearer the base than the first two branches of the scapular, the first simple, the other forked simply in the middle of its course; and farther apart and from these, two other simple branches, the first opposite the fork of the preceding branch; all of these branches on approaching the border sweep in a more longitudinal course toward it. The anal furrow is not deeply impressed, a little roundly bent beyond the middle, otherwise nearly straight; the anal veins are not preserved, but the furrow appears to strike the inner margin slightly before the middle of the wing. There is no sign of any transverse venation or reticulation.

The breadth of the wing is 12.5 mm.; the length of the fragment 17 mm.; and the presumed length of the wing about 26 mm.; making the breadth to the length as 1 : 2.1. It could hardly have been much longer than that, and would need be very much longer to have had the same proportions as *L. pennsylvanica* to which it is the more nearly allied; the disposition of its nervures is very similar to what we find there, and even if the proportions given are (as they possibly may be) very much out of the way, it is a much larger species than it, being half as broad again. It differs also slightly in neuration, as in the forking of some of the scapular veins, and particularly in the much earlier branching and greater significance of the externomedian vein, which is exceedingly unimportant in *L. pennsylvanica*; the entire disposition of the internomedian veins is also different and they play in this species a much less prominent part than in *L. pennsylvanica*. From the other species it is as widely separated as is its ally.

The specimen was obtained by Mr. R. D. Lacoe, and bears the number 2041 in his collection. It was found at the Port Griffith railway cut near Pittston, Pa., over the E vein and probably over the F vein.

BLATTINARIAE Scudder.

The species to add to this group of carboniferous cockroaches are really more numerous than those from the Mylacridae; but only a few of them are here selected, as the larger part are still unstudied, and there are no new generic types to be found among them, though one, the last described below, belongs to a generic type not before recognized in American rocks.

Etoblattina occidentalis sp. nov.

Pl. 32, fig. 4.

Fore wing long and slender, its greatest width before the middle; the costal margin is rather strongly convex on the basal quarter of the wing, and scarcely at all convex in the middle; the inner margin is gently convex but nearly straight in the middle and the apex is tapering and well rounded. The veins originate at about the middle of the somewhat constricted base, and all curve considerably upward in separating, excepting the anal furrow. The mediastinal vein runs closely parallel to the costal margin, nearly to the middle of the wing, and then curves toward it, terminating only a little before the end of the middle third; it emits a considerable number of equidistant, obliquely curving, simple branches, of which there are about seven in the distal half of the field. The scapular vein runs still more nearly parallel to the costal margin as far as the middle of the wing, and then sweeps very gradually toward it, reaching it only a very little before the tip of the wing; beginning to branch about opposite the end of the anal furrow, it emits about half a dozen subequidistant, simple or simply forked, nearly straight but slightly sinuous branches, which are more longitudinal than those of the preceding area; in the middle of the wing this area and the preceding occupy scarcely two-fifths its width. The externomedian vein divides close by the divarication of the scapular; previous to forking, it is regularly and considerably arcuate; it is now straight at first, but afterwards appears to take on a sinuous course, obscured in the only specimen; it emits three or four principal longitudinal branches which dichotomize somewhat, especially in the apical third of the wing, the nervules curving downward more or less as they approach the margin. The internomedian vein follows closely the course of the externomedian and apparently terminates a little further out than the mediastinal; it emits in the basal half of its course five or six more or less curving, generally simple veins, and doubtless an equal number beyond, but this part is obscured in our fossil. The anal furrow is remarkably pronounced, strongly and regularly arcuate, terminating scarcely beyond the end of the basal third of the wing, and followed in the anal area by seven or eight equidistant, similarly arcuate, simple veins.

The wing is of good size, being 32 mm. long, and 12 mm. broad, or the breadth to the length as 1: 2.7.

A portion of one of the hind wings also shows between the partially opened fore wings, and some few veins of a hind wing appear mixed with those of the right fore wing. Little can be determined from these fragments, for to judge from the first, the hind wing must have been of the same length and very much indeed of the same form as the fore wing, with a similar distribution of veins; while to judge from the latter, in the position it holds, the neuration must have been very much more developed in certain areas.

This insect is more nearly allied to *E. lesquereuxi* than to any other species, but differs from it in many features, such as the equality of the mediastinal area, its more frequent veins, the greater regularity of the scapular branches, and especially the earlier divarication of the externomedian vein, with its consequently larger area, as well as the general disposition of its branches. It is also allied, but not so closely, to *E. mazona*, a smaller species, differing from it in a shorter and more uniform mediastinal area, a different distribution of the veins of the scapular vein, an earlier divarication of the externomedian vein, and, apparently, a much shorter internomedian area.

The specimen is preserved with some of its natural brownish coloring on a light clay-colored stone, and the better half shows a deep impression of the anal area which must have been well vaulted; the other half, showing the upper surface, is not so well preserved. It comes from the old Fair ground at Lawrence, Kansas, and was sent me for examination by Mr. R. D. Lacoe, in whose collection it bears the number 2045ab.

Archimylacris paucinervis sp. nov.

Pl. 31, fig. 5.

The fore wing is long and rather slender, nearly equal, the costal margin, however, somewhat and rather regularly convex (too convex upon the plate), the inner margin straight throughout the greater part of its course, the tip somewhat tapering, a little produced and rounded; the broadest part of the wing is near the middle or a little before it. The mediastinal vein runs in a nearly straight course, very nearly to the end of the second third of the wing, and emits a considerable number (from eight to ten) of mostly forked or doubly forked branches; they differ a little in the two wings, that of the right wing having a fewer number of branches, and they are also more regularly branched; the greatest width of the area is considerably less than one quarter that of the whole wing. The scapular vein runs in a nearly straight line toward the outer margin which it nearly reaches a little before the tip, and then curves a little downward to terminate on this margin a very little before the tip; with its branches it occupies a narrow wedge-shaped area which at the tip of the wing is scarcely more than half its breadth; it emits at the end of the first third of the wing a single branch at a slight angle, which bears all the other branches, excepting a few, mostly simple, short branches which separate from the main stem near its tip upon the upper side, filling the space left unoccupied by short branches beyond the tip of the mediastinal vein; this principal branch reaches the apical margin a little below the apex of the wing and acts differently in the two wings: on the left side it emits two superior branches near together near the end of the second third of the wing, the first simple, the second forked near the tip; on the right wing it forks a

little before the end of the middle third, a very little sooner than on the opposite wing, and each of these branches is again forked, the upper the nearer to the outer margin, and at the same distance from it as the apical fork of the opposite wing. The externomedian vein also differs in a single point very markedly in the two wings; it occupies more space by its earlier division in the left wing, but in neither does it differ much from the preceding in the extent and form of the area which it covers: in the left wing it divides at the end of the basal third of the wing, just beyond the initial forking of the scapular vein; in the right it does not fork until it has reached the middle of the wing; notwithstanding this difference the rest of the area has the same aspect; the lower branch forks a little beyond the middle of the wing, and the upper at about the end of the middle third, the nervules being entirely simple, and this brings the secondary forking of this vein close to its primary forking in the right wing, although far from it in the left. In addition to these peculiarities, this vein possesses another in the presence of a short cross vein running obliquely like an ordinary branch from before the end of the basal fourth of the wing to the internomedian vein, which it strikes at or barely beyond the origin of the second branch of the same. The internomedian vein with its outermost branch strikes the inner margin near the middle of the outer half of the wing, thus occupying on the border considerably more space than either of the preceding two veins; it is considerably arcuate and emits from its lower border three principal veins, the first two simple, the outermost forked, and differing in the two wings; the first vein is sent forth opposite the base of the cross shoot of the preceding vein, the next a little beyond it or a little before the end of the middle third of the wing, while the third originates at a greater distance off, in the middle of the wing opposite the fork of the lower branch of externomedian vein: on the left wing, the inner fork is simple, the outer forked again in the middle of its course, or it might be said that the main stem had four principal and all simple branches; in the right wing, both forks subdivide, the inner halfway, the outer at much less than halfway, to the margin. The anal furrow is very arcuate near the base and at this part deeply impressed, beyond nearly straight and hardly impressed, running very obliquely and terminating on the inner margin not very far before the middle of the wing; the anal veins count about eight at the margin; they are much simpler on the right than on the left wing, having in the latter three which fork and one of these an interpolated one which connects with those on either side by an oblique cross vein; while most of those on the right wing are simple, one forking close to the base, another near the middle; they are all considerably arcuate. The differences therefore between the two wings are considerable in the minuter details, though important only in the first branching of the externomedian vein, which strangely does not affect the subsequent offshoots of the same.

The hind wing of each side is also present to a considerable extent. More perhaps can be said of its form than in almost any other paleozoic cockroach hitherto described. The wing, except in lacking altogether any convexity in its straight costal margin until the narrowing of the wing begins toward the apex, closely resembles in form the fore wing; it is of just about the same length and breadth also, a point which appears to distinguish the ancient from the modern types; so far as we know, the hind wings of the former gradually taper apically to a well and very regularly rounded apex. It should be

particularly noticed that its form as well as the character of its main venation bears a striking resemblance to the wings of Dictyoneura and its allies. The only well marked difference is, perhaps, in the costal area where its alliance to the fore wing of the Palaeoblattariae appears. Owing to the obliteration of the attachments of the main veins, very great uncertainty must remain as to the normal veins to which any of the longitudinal nervures belong; the mediastinal vein, however, is clearly marked; it runs in very close proximity to the margin, not farther from it than the other nervures are separated from each other; it terminates just about as far from the tip of the wing as in the front wing and emits a large number of necessarily short but very oblique and generally forked branches. Following it are at least five principal nervures, all of which seem to belong to preanal areas, but any two or more of which may belong to the same principal vein, so far as anything can be stated from this specimen. The first, counting from the mediastinal vein, is forked at a point exactly similar to the basal forking of the scapular vein of the fore wing and in a similar way, and hence may be presumed to be that vein; this basal forking of the presumed scapular vein can only be seen in the left wing, where the upper branch is simple; the lower branch, however, is seen distinctly in both wings to fork exactly opposite the second forking of the lower scapular branch of the upper wing; the forks, however, act differently in the two hind wings: on the left side they both fork, the upper halfway, the lower three-quarters way to the margin; on the right side, the lower is simple, while the upper forks before the middle and its lower branch forks again halfway on its course; the number of nervules reaching the margin is thus the same and they cover the same narrow space, the lowermost striking the tip. Judging from the analogy of the upper wing, the next two nervures, which are exactly alike in the two hind wings, belong to the externomedian vein, in which case they repeat almost exactly the characteristics of the same vein in the upper wing of the left (but not of the right) side, forking first (to judge from the gradual approximation of the two nervures baseward) at or a little before the end of the middle third of the wing, the lower fork again branching at some distance beyond the middle of the wing, and the upper halfway between this and the tip. Below these are, first a forked nervure and then a simple one, both of which probably belong to the internomedian vein, but do not resemble the same part in the upper wing; the forked vein forks as far from the margin as (but of course further from the tip than) the upper externomedian branch: in the left wing it is simply branched; in the right it sends a similar offshoot from both sides of the stem, *i. e.*, it divides into three at the same point; all these nervures are very long and straight with a slight downward sweep as they approach the margin, especially in the upper part of the wing; they are about as distant from each other as in the upper wing but, particularly, the lower ones are less oblique; on the left wing there is also another fragment of a simple vein, as far below the lowest mentioned as the latter is from its predecessor and trending slightly toward it baseward; it probably also belongs to the internomedian vein.

Besides the wings, a part of the pronotal shield is present, and the limits of the abdomen are partly marked by a depression. The former is nearly semicircular, somewhat broader than long, very regularly rounded in front, the sides very slightly divergent behind the middle; the posterior edge appears to be scarcely convex; a little to the outside of the middle of either lateral half is a slight rounded furrow or depression, less curved

than the margin and passing faintly around the front close to the margin; a subcircular flat depression nearly a third as broad as the shield rests upon its posterior margin; the edge of the shield is very delicately marginate.

The abdomen is remarkably slender like that of *Etoblattina? insignis*, as mentioned in my memoir on Palaeozoic cockroaches, being scarcely more than a third as broad as this pronotal shield, and extending beyond the middle of the outer half of the closed wings; a few incisures marking segments can be seen, but the whole contour is exceedingly vague.

The insect is of pretty large size, much larger indeed than the other species of the genus, the fore wings measuring 30.5 mm. long and 10 mm. broad, the proportion of the breadth to the length being as 1 : 3, making it also slenderer than the other species. The length of the whole body from front of pronotal shield to tip of abdomen is 29 mm., the pronotum itself being 6 mm. long and 7.75 mm. broad and the abdomen about 3 mm. broad. The specimen is unusually perfect, both fore wings being nearly complete, as well as the apical half of both hind wings, and most of the pronotal shield; the latter is in its natural position in relation to the partly expanded wings, but the direct connection with it is broken; the abdomen is only traced by a depression in one stone and a rough ridge in the reverse. The front wings are covered throughout with a delicate but readily traceable reticulation, consisting of very irregular polygonal cells in all the areas but the mediastinal, internomedian, and anal, where the nervules are united by frequent uncertain or wavy cross veins into subquadrate cells, usually square in the mediastinal area and broader than long in the others; in the latter, too, and especially in the internomedian area, they tend next the margin of the wing to change to the irregular polygonal reticulation.

This species differs decidedly from either of the species of this genus hitherto known. It is larger and has a much slenderer wing than either. The scapular area is of considerably less extent, the vein far less branched, and the mode in which its branches are distributed very different; its internomedian area is also much more restricted than in the others.

The specimen occurs in an ironstone nodule found at Morris, Grundy Co., Illinois, and was discovered by Mr. J. C. Carr of that place, through whose kindness I have been able to examine it. It is now in Mr. R. D. Lacoe's collection with the number 2011.

It may be added that this specimen is of particular interest as having the wings more completely preserved than in any other paleozoic cockroach yet known, and offers even a better example than *Anthracoblattina sopita*[1] for comparison of the neuration of opposite wings; it leads us to hope that future discoveries may enable us by correlating these differences to determine the distinction between individual and specific characters among ancient cockroaches,—a question we are hardly yet in a position to discuss.

Oryctoblattina occidua.

Pl. 32, fig. 3.

Oryctoblattina occidua Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 37.

The single specimen known lies in the half of a nodule, and shows the larger part of

[1] *Cf.* Scudder, Palaeozoic Cockroaches, Mem. Bost. Soc. Nat. Hist., III, 89 (1879). Geinitz, Blattinen unter. Dyas v. Weissig, Nova, acta Leop-Carol. Akad., XLI, 423 (1880).

the two front wings, slightly parted and vague indications of the thorax and possibly of the legs. The prothorax is quadrate, pinched transversely in the middle to a definite ridge, which is probably accidental. The legs, if the elevations near their position may be taken to indicate their appearance, must have been very short and tolerably slender.

The front wings are rather slender, the tip well rounded and slightly produced, the costal margin slightly shouldered at the base, beyond nearly straight in the basal half, apparently sloping downward beyond, the inner margin apparently broadly rounded but the basal half not clearly indicated in the specimen. The veins appear to originate from the middle of the upper half of the base of the wing, and have scarcely the least basal arcuation. The mediastinal vein runs at but slight distance from and nearly parallel to the costal border, in the outer half or more constantly but very gradually approaching it, emitting numerous oblique generally simple branches; the vein terminates in the middle of the outer half of the wing, and shows no such peculiarities at its tip as characterize the European species. The scapular vein also is not so peculiar as in *O. reticulata;* it runs in near proximity and parallel to the mediastinal vein, but there is the same slight bend in its course at the base of the principal branch; the mass of the branches, which are much fewer than in *O. reticulata*, do not arise as there from a vein emitted abruptly from near the base of the second branch, to which they are inferior, but from the principal branch itself, to which they are superior. Less can be said about the other veins, as they are obscured throughout most of their course, but the internomedian vein terminates at about the end of the middle third of the wing and has only few branches; and the externomedian branches all terminate on the inner margin.

The wing is 19 mm. long, and 7 mm. broad, the breadth to the length being as 1 : 2.7. It is reticulated minutely, as in the European species, and is interesting as being the second species of the genus known, and as illustrating once more the close relationship of the insect fauna of Europe and America in carboniferous times. It is a smaller and slenderer species than the European.

It comes from the beds of Mazon Creek, Illinois, and was sent to me by Mr. R. D. Lacoe, in whose collection it bears the number 2039.

EXPLANATION OF PLATES.

PLATE 31.

Figs. 1–4 by Mrs. Katherine Peirson Ramsay; fig. 5 by J. S. Kingsley; figs. 6–7 by J. H. Emerton.

Fig. 1. *Promylacris ovalis*, $\frac{2}{1}$ cast.
" 2. *Promylacris ovalis*, $\frac{2}{1}$ side view.
" 3. *Promylacris ovalis*, $\frac{2}{1}$ cross section of prothorax in middle.
" 4. *Promylacris ovalis*, $\frac{2}{1}$ relief.
" 5. *Archimylacris paucinervis*. $\frac{3}{1}$
" 6. *Promylacris rigida*. $\frac{3}{2}$
" 7. *Paromylacris ampla*. $\frac{3}{2}$

PLATE 32.

Figs. 1–2 by J. S. Kingsley; figs. 3–4 by Mrs. Katherine Peirson Ramsay; fig. 5 by S. H. Scudder; fig. 6 by J. Henry Blake.

Fig. 1. *Paromylacris rotunda;* $\frac{2}{1}$ cross section of thorax in middle.
" 2. *Paromylacris rotunda*. $\frac{2}{1}$
" 3. *Oryctoblattina occidua*. $\frac{3}{1}$
" 4. *Etoblattina occidentalis*. $\frac{3}{1}$
" 5. *Lithomylacris pauperata*. $\frac{5}{2}$
" 6. *Promylacris testudo*. $\frac{2}{1}$

X. New Carboniferous Myriapoda from Illinois.

By Samuel H. Scudder.

Read May 7, 1890.

THE publication of my paper on Archipolypoda, eight years ago, in which a considerable number of new types of American carboniferous Myriapoda were described, has so stimulated search in this country that, thanks to the kindness of many friends and particularly of the indefatigable Mr. R. D. Lacoe, there has since passed under my eyes a much greater number of specimens than I had then seen, and as they contain not a few additional and some remarkable forms, as well as throw more light upon the old, it has seemed well to bring them together in a systematic way, and to present some tables by which they may be distinguished, when sufficiently perfect. Accordingly there are here published such as have been found at Mazon Creek and vicinity leaving for a future paper several new forms which have been found in the sigillarian stumps of Nova Scotia. The sources from which the specimens were received are in all cases indicated, and the paper concludes with a summary list of known American species of palaeozoic Myriapoda.

TABLE OF THE ORDERS OF PALEOZOIC MYRIAPODA.

Each of the principal body segments composed of a single dorsal and single ventral plate, each of the latter with a pair of legs. Body usually unarmed.

Head apparently formed of a single segment. Dorsal plates of body supporting clusters of needle-like spines on serially ranged tubercles. Legs stout and fleshy . . . . . **Protosyngnatha.**

Head apparently formed of two or more segments. Dorsal plates of body sometimes furnished with lateral expansions but otherwise unarmed. Legs slender and horny . . . . . **Chilopoda.**

Each of the principal body segments composed of a single, but more or less distinctly divided dorsal plate and a pair of ventral plates, each of the latter with a pair of legs. Body generally armed with spines or tubercles serially arranged . . . . . **Archipolypoda.**

Only the Chilopoda and Archipolypoda will be considered in the present paper, as I have nothing to add concerning Palaeocampa, the sole representative of the Protosyngnatha.

Order CHILOPODA Latreille.

It has not been supposed that this group of myriapods reached further back than the Jura or even than the tertiaries, for its only claim to recognition in the secondary rocks

is Münster's *Geophilus proavus*, which is very probably not even a myriapod. The nearest proof of the appearance of the order in paleozoic deposits is in the possible judgment of some that Palaeocampa (which bears somewhat the same relation to Chilopoda that Euphoberia does to Diplopoda) should be taken as one of them. No one has made such a claim, and should one do so he would have to recognize in Palaeocampa a highly organized and very aberrant type. But not only do specimens received in recent years from Mr. R. D. Lacoe and Mr. W. F. E. Gurley, but especially from the former, show that Eileticus was nearly allied to the Scolopendridae, and either belonged to the Chilopoda, or was an archaic type to be looked upon as its forerunner; but a single specimen from Mr. Lacoe has also revealed still a second type of chilopodiform character, an ancient type of Scutigeridae. These discoveries carry the chilopodiform line much further back than it was believed it existed, and so far as the record goes renders nugatory much of Dr. Packard's reasoning concerning the greater antiquity of the Diplopoda (Proc. Amer. Phil. Soc. XXI, 206–207), though the occurrence of the diplopodan line in the Scottish devonian should not be overlooked.

The indications of the presence of heavy armature in some of these chilopodiform carboniferous myriapods, together with the character of the segments, and the features by which they show kinship to their contemporaries rather than their descendants, lead me to believe that when more is known about them, they may prove to form an archaic type distinguishable as a whole from the later chilopods, as the Archipolypoda from the diplopods; but the incompleteness of our knowledge of their structure leads me to wait for further light and meanwhile to place them in distinct families separable from their evident successors by trenchant characters.

Gerascutigeridae fam. nov.

Body relatively short. Head no broader than the body. Dorsal scutes of the same number as the segments and corresponding to them, much broader than long, with no evidence whatever of mediodorsal stomata. Coxæ extending beyond the sides of the body, followed by femora of excessive length.

Latzelia gen. nov.

Of the general aspect of Scutigera but differing essentially at every point. The head is vaguely preserved, and none of its appendages can be seen. The body is broadest in the middle, and tapers gradually and about equally in each direction, giving it a rounded fusiform appearance, and the head does not interfere in the least with this outline, so that it is scarcely half as wide as the middle of the body. The segments, to which the dorsal scutes exactly correspond (so different from Scutigera), are subequal in length, and apparently nineteen in number, certainly not more than one or two segments away from that; in the middle of the body where widest they are about four times broader than long; both front and hind margins are entire, showing no trace of a recess to favor the presence of stomata. The legs are nowhere completely preserved, but are apparently unequal in length and slender, as in Scutigera, and at shortest more than half as long as the body, apparently very much as in Scutigera; but their composition is very different; the coxae

are even more prominent than in Scutigera and notwithstanding the more robust body project much further beyond the sides; but in addition the femora are of excessive length and slenderness, slenderer than the coxae and half as long again as the width of the very broad body, and taper from base to apex; to judge by appearances these two members constituted the larger, instead of as in Scutigera the smaller, part of the leg, but this cannot be asserted; probably however the tibiae and the (multiarticulate?) tarsi together were no longer than the femora.

The genus is named in honor of Dr. Robert Latzel of Vienna who has so much advanced our knowledge of the Myriapoda.

Latzelia primordialis sp. nov.

Pl. 38, fig. 3.

The single specimen is found in a small nodule which at the two extremities cuts off the appendages, but offers no hindrance to the full expanse of the members laterally, though their full length cannot yet be seen. The main features have been described above under the family and genus, both of which have their source in this single specimen. No part of the antennae is preserved. The body segments, however, show a peculiar structure; not only are the front and hind margins entire and transverse, permitting no opening to the position of the mediodorsal stomata found in Scutigera, but most of the segments (all where not obscure) show a distinct, marked and sharp mediodorsal carina extending the whole length of each segment, but somewhat obscure posteriorly over just about so much of the dorsal shield as in Scutigera is emarginate for the stomatal opening; and on either side of this carina, all the segments, but especially the median ones, show a pair of diverging sulci, twice as distant posteriorly as anteriorly, crossing the entire segment, and posteriorly as far apart as the length of the segment; sometimes also showing faint traces of continuing upon the segment next posterior. The body itself is slightly arched transversely.

The legs are similarly constructed, but the median ones are evidently stouter than those at the extremities, to a slight degree. Both coxae and femora show the median half transversely arched, while the sides show nothing of the sort, or sometimes interiorly, next the transverse arching, a broad longitudinal sulcus, all giving the appearance of a depressed leg with a median rounded longitudinal ridge, very common in the Archipolypoda.

Length of body, 22.5 mm.; breadth in middle, 4.5 mm.; length of coxae in middle of body, 2.3 mm.; of femora in same, 6.5 mm.; breadth of same coxae, 0.9 mm.; breadth of same femora at base, 0.7 mm.; at tip, 0.5 mm.

Mazon Creek. Mr. R. D. Lacoe, No. 1837ab.

Eoscolopendridae fam. nov.

Head evidently formed of two principal segments, but these much more closely fused, separated only by sulcations or blind sutures. Body segments numerous and similar, each bearing a single pair of legs and having a single dorsal and ventral plate, the former

sometimes furnished with tubercles. Much remains to be learned of the structure of all the animals here brought together.

Eileticus Scudder.

As already remarked, the discovery of better remains proves that this genus finds its place better here than in the Archipolypoda. The imperfection of the only specimen known when this genus was founded led to several errors of interpretation which may now be corrected. The head was not composed, properly speaking, of a single apparent segment, but of two, a larger anterior and smaller posterior segment, each with its independent vaulting, the hinder with a pair of foot jaws arising from its posterior portion; but the two segments are not separated as in modern chilopods by a distinct suture, but only by a broad and shallow transverse sulcus from the meeting of the two arches. Nor do any of the segments bear, as was judged from the appearance of the non-attached anterior members of the original specimen, more than a single pair of legs, but very little can be said about them. The form of the segments and their tuberculation would appear to be subject to some variation. No complete specimens have been found, nor any in which more than thirteen or fourteen segments behind the head are preserved.

Eileticus anthracinus.

Pl. 38, fig. 5.

Eileticus anthracinus Scudd., Mem. Bost. Soc. Nat. Hist., III, 179 (1882).

Another specimen of this species, far more perfect than the first and with its reverse, has been found at Mazon Creek, and sent me by Mr. Lacoe, in whose collection it bears the number 1835ab. It exhibits the dorsal surface of the anterior extremity, very likely about half the body, but fragmentary and without appendages, of an animal of about the same size as the original. It shows about thirteen segments besides the head. The latter, broken in front, shows a flattened globular mass of smooth texture, with a faint transverse median impression separating independently though faintly arched anterior and posterior portions; a longitudinal median impression of similar depth crosses both but is not accompanied by an independent arching of the head in the other sense; from the middle of the posterior margin of either lateral half of the hinder section of the head arises a decided, cornuous, tapering, forward and downward reaching, independent arched member, plainly representing the foot-jaws.

The segments of the body are sub-equal in length, but enlarge in breadth in passing from the first behind the head where it is slightly narrower than the head to about the sixth segment, beyond which they are about equal; each, when perfectly preserved, shows a transverse, marginal, strong and abrupt, rounded sulcation at its anterior edge, the margins of which are prominent, and the hinder at a much higher level than the anterior or proper margin of the segment. The surface of the segment is smooth and uniform, except that at the extreme lateral margins, as in the original specimen, are seen more or less distinctly small tubercular bosses serially arranged. The best preserved segments appear to be a little more than twice as wide as long.

Length of fragment if extended, 48 mm.; breadth of head, 6.4 mm.; greatest breadth of body, 8 mm.

Eileticus aequalis sp. nov.

Pl. 38, figs. 6–9.

A second species seems to be indicated by a couple of specimens from the same locality sent me by Mr. Lacoe under the numbers 1836ab and 1836cd, both shown in obverse and reverse. The better of these (figs. 6–8) is a remarkably well-preserved but very fragmentary specimen, showing the dorsal view of the front part of the body consisting of the head and eleven segments. The head closely resembles that of the specimen of the last species just described, but has more accentuated sulcations both longitudinal and transverse, and the foot-jaws are more pronounced even than there; as there, also, the front of the head is broken, but on the reverse, what appear to be the first two joints of an enormous antenna project laterally, in which case the antennae are broader at the base than the very base of the foot-jaws.

The segments of the body have a smooth texture, and the same transverse stepped sulcation that occurs in the preceding, but with less prominent edges; still it differs from it markedly in that the segments are almost absolutely uniform in size; they have a lateral depressed and horizontal flange with a rounded edge, while the main body is strongly arched, and the lateral flange bears such slight tuberculations as can be seen; without this flange the body is slightly narrower than the head; with it a little wider; the segments without the flange are a little more than three times as broad as long.

Length of fragment, 26.5 mm.; of one of the principal segments, 2.3 mm.; breadth without flange, 7.25 mm.; with it, 10 mm.; breadth of head, 7.75 mm.

The other specimen (fig. 9) is similarly preserved but more imperfect, one whole side being broken, and the head far less complete. There is little to be said about it, but its transverse arching shows that it was nearly cylindrical; and the posterior as well, but not to the same extent, as the anterior margin of the segments has a stepped transverse sulcation. The head is far less perfect, but as far as it goes shows precisely the same features; the body segments are thirteen in number, and show by their apparent inequality in length that there was greater or less power of extension by elastic intersegmental membranes. No one of the segments is perfect, so that the proportions cannot be stated, and only one side is approximately perfect, and that does not preserve the lateral flanges; but enough remains to show that the specimen by its equality of breadth belongs to this rather than to the preceding species.

Length, 50 mm.; breadth of head, 7 mm.

PALENARTHRUS gen. nov. (*πάλαι*, *ἔναρθρος*)

A genus evidently very different from anything before known from the carboniferous rocks, but unfortunately known only by a single specimen, which from its incompleteness leaves much to be desired. That it was a scolopendriform chilopod or archaic type of chilopod is evident from the flattened rectangular plates of which the dorsal surface of

the body is composed, each accompanied by a single pair of legs. What is peculiar about it, is not only its tapering form anteriorly but its great attenuation at this extremity, indicating apparently a remarkably small head followed by a slender neck of at least two elongated segments, which do not appear to be pedigerous; these neck-segments are fully twice as long as broad, and not only do the segments behind them taper as they approach them, but the anterior of these two is the smaller and narrower and not a fourth nor probably a sixth as broad as the broadest segments of the body. The legs are poorly preserved, about as long as the breadth of the body (relatively longer in front) and apparently have very prominent coxae, as in other carboniferous myriapods.

Palenarthrus impressus sp. nov.

Pl. 38, fig. 4.

The single specimen probably represents nearly the whole animal, though neither end is shown; it is hardly probable that anything more than the head is wanting at the anterior extremity, but posteriorly an indefinite number of segments. There are twenty-three segments in all. The first two behind the head are slender and twice as long as broad, the third subquadrate, the four or five succeeding broader than long, of subequal length, but increasing breadth in passing backward; thereafter they appear to be of the same size, about twice as broad as long and rectangular, the front outer angle sometimes a little produced. The first two elongated segments show a slight median carina; the fourth and succeeding ones on either side a laterodorsal series of large circular depressions next the anterior edge.

Length of fragment, 46 mm.; breadth of first body segment, 1 mm.; of seventh, 5 mm.; length of legs, 3 mm.

Mazon Creek. Mr. R. D. Lacoe, No. 1821ab.

Ilyodes gen. nov. (ἰλυώδης)

I venture to propose this name for some obscure forms in the hope of stimulating further search for more perfect specimens to elucidate their structure. One of them is plainly chilopodiform, though very different from anything we know; there is certainly but a single pair of legs to each segment, though the line of separation of the segments is obscured by the curious transverse sculpture of the dorsal plates; but we are aided in our determination by the presence of serial tubercles. These latter, or their reverses, also occur on the taenioid body of a second form which has no legs preserved, and which is provided with such a multitude of short transverse segments that it would seem impossible that it could have possessed more than a single pair of legs to each; it reminds us somewhat of Geophilus. The only points these have in common are that they are composed of a large number of similar transverse segments each bearing a single pair of legs and furnished with serial rows of tubercles.

Ilyodes divisa sp. nov.

Pl. 38, fig. 1.

The single specimen referred here is a straight fragment composed of fourteen simi-

lar segments shown apparently upon a side view, the lower edge of the segments irregularly broken so that their exact proportions can hardly be told, though some of the legs are partly preserved; there is no indication, however, that the segments varied in size, and all were probably about half as broad again as long. They show two features: first, each segment is composed of a series of equal and similar slight transverse ridges, about eight in number; these ridges are more or less tremulous or sinuous, and slightly uneven, presenting faintly a beaded appearance; second, there is a lateral series, one to a segment, of rather large tubercular bosses, irregularly rounded, upon the very front margin of the segments. The legs are very obscure, and their jointing, as shown in the figure, altogether uncertain; as far as preserved, which may very well be not to their extremity, they are shorter than the breadth of the body.

Length of fragment, 48 mm.; apparent breadth, 5.5 mm.; average length of segments, 3.6 mm.; diameter of tubercles, 1.5 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1830ab.

Ilyodes elongata sp. nov.

Pl. 38, fig. 2.

The single specimen which represents this species is formed of two masses, one L-shaped and overlying the other which is U-shaped; evidently both belonged to the same individual, and their connection could have been traced had the stone been broken open more favorably. The division line between the segments cannot be everywhere traced from the obscurity of the preservation on the stone, but there are present evidently at least one hundred and sixty-six segments, which differed apparently not over a sixth in width and that little perhaps due to a twist in the body as laid down; they differed, it would appear, as little in length, being almost uniformly about three and a half times as broad as long; they show no sculpture whatever, but an obscure series of small depressions in the middle of the segment next the suture; if the creature where these so appear were lying on its side, these depressions would hold precisely the position of the tubercles in *I. divisa* and may represent the cast of weaker tubercles.

Length of whole if extended, 65 + 96=161 mm.; breadth, 3.5–4 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1829ab.

Order ARCHIPOLYPODA Scudder.

It is in this order that the principal additions in specific forms are to be found, and they are mainly in the family Euphoberidae from which, as already stated, the genus Eileticus must be removed. It is, moreover, not impossible that future discovery of more perfect specimens may show that Amynilyspes should be regarded as one of the Diplopoda (allied to the Glomeridae) rather than as a member of the Archipolypoda; but the apparent necessity of ventral plates of excessive width and the known armature of the dorsal plates render it proper to retain it in the Archipolypoda until its structure is better known, or at any rate until undoubted Diplopoda are found at so early a period.

Family Euphoberidae Scudder.

Acantherpestes Meek and Worthen.

Acantherpestes major.

Acantherpestes major Scudd., Mem. Bost. Soc. Nat. Hist., III, 150 (1882).

Mr. R. D. Lacoe has sent me several new specimens of this species, which appears to be not uncommon at Mazon Creek, but they add little or nothing to what has previously been published. The best specimen (No. 1801de) exhibits about twenty-four segments of the body, neither end of which appears. The spines are nowhere well preserved, but the legs are partly shown at each extremity, and seem to be unusually broad, flattened, and crowded, with no sign of any median carina; although the specimen is not of the largest size, the fragment measuring about 15 cm. in length, and at most 17 mm. in breadth, the legs are 1.5 mm. broad in the middle.

Another specimen of this species, from Mazon Creek, sent me by Mr. W. F. E. Gurley, consists of a fragment from the middle of the body, of twelve segments preserved upon a side view, the spines of the subdorsal series showing finely, but no trace of legs. The body is curled slightly backward, as is most common in the specimens so far found, and the segments are 20 mm. high and in the middle 7 mm. long on an average. The spines are about 15 mm. long, the apical 4.5 mm. concerned in the furcation; the forks are deeper than usual, and the boss on which they are seated is 2 mm. high.

Finally, a smaller specimen, presumably of this species, likewise from the middle of the body and about 11 cm. long, from Mazon Creek, is in the museum of Columbia College, the opportunity of examining which I owe to Dr. J. S. Newberry. It is also preserved upon the side, shows no legs, and only indications of the subdorsal spines, the pleurodorsal indicated by abraded bosses. It contains nothing to add to the structural peculiarities of the species. It is made up of sixteen segments which are about 14 mm. in height.

Acantherpestes inequalis sp. nov.

Pl. 33, figs. 2, 4.

Two specimens of gigantic myriapods have been sent me, one by Mr. R. D. Lacoe, the other by Mr. J. C. Carr, but now in the possession of the former, which are clearly distinct from anything hitherto known. Although very differently preserved and showing very different characters, they seem to belong together since they agree in the one feature of the inequality of the tines of the forked spines.

One of them (fig. 2), received from Mr. Carr, but now numbered 1819ab, in Mr. Lacoe's collection, is a fragment of the anterior part of the body preserved to show a completely dorsal view. The head is transversely oval, but shows no structure; about a dozen segments are preserved, showing that the body tapered forward, and that the first segment was much narrower than the head, unless, as is very probable, the latter is unnaturally crushed; the first few segments are very short and broad, but posteriorly they enlarge and lengthen, so as to be only about three times as broad as long, and present a somewhat coarse granular structure. The armature, however, is the most interesting

feature; the lateral spines extending on either side are fully as long as the width of the body, sometimes considerably longer, and are remarkable for the great length and inequality of the forks, at least from the fifth segment backward, the longer fork being posterior and diverging from the other and sometimes as long as the stem of the spine itself; there are, besides, basal thorns both anterior and posterior, of varying length but the anterior usually the longer and sometimes very long and slender. The subdorsal row of spines is clearly indicated by bosses (or pits in the obverse) upon most of the segments; the pleurodorsal series is not so clear, but appears to be indicated, posteriorly, by the extremities of apparently simple spines which protrude laterally beyond the sides of the body between the lateral spines. There is besides, protruding from the posterior extremity of the sixth segment, just as I described it in *A. major*, a long slender stiff rod, here thrust sidewise and thrown a little forward, longer than the width of the body.

The length of the specimen is 63 mm.

The second specimen (fig. 4), received from Mr. Lacoe, under the number 1819cd, shows only the posterior part of the animal and in an entirely different position. It is preserved upon a side view, and shows about eighteen segments though only ten are here figured. Here only the dorsal spines are shown, and they differ remarkably from the others in being almost boot-shaped, the longer posterior fork being almost the only one developed; this is inclined at a strong angle with the stem, and is nearly as long as it; moreover, the whole is short and stumpy, less than half as long as the width of the tapering body, excepting on the posterior segments, and the anterior fork is only indicated by a slight projection at the heel of the boot; as, however, they agree with those of the lateral row in the other specimen (and not seen here) in the unequal length of the forks, which mainly distinguishes either from *A. major*, they are placed together until further light is obtained from other specimens. The legs are fairly well preserved, are not closely crowded, slender, with only slight sign here and there of a median carination, taper very regularly beyond the middle to a point, the last joint the shortest, the preceding three subequal and only a little longer; at the hinder extremity of the body they about equal in length the width of the body, but a dozen joints away, while of the same length, they do not more than equal half the breadth of the body. The length of the fragment is 93 mm.; the legs are about 9 mm. long. The spines of the other rows do not plainly appear, but their place is here and there obscurely indicated.

It remains to be seen whether we are here dealing with two species, but the complete and striking inequality in the forks of the spines will not allow us to look on them as belonging to *A. major*, to which at first sight they have a striking resemblance. Neither of these specimens indicates quite so large a species as that, though much stouter than any species of Euphoberia.

Mazon Creek, Ill.

Euphoberia Meek and Worthen.

I subjoin a table of the species of this genus known up to the present time in North America.

TABLE OF THE SPECIES OF EUPHOBERIA.

Body stout.
- Very large species, with large bristling spines having large basal spinules.
  - Largest of all, with spines like *Acanth. major* but more deeply forked, not very divergent and with basal spinules both anterior and posterior . . . . . **E. hystricosa.**
  - Smaller with more delicate spines and only posterior basal spinules . . . . . **E. horrida.**
- Ordinary sized species with more delicate compound spines, the basal spinules not so highly developed.
  - Spines long; spinules highly developed.
    - Surface sculpture delicate; body largest on segments 12–18, tapering gradually each way **E. armigera.**
    - Surface sculpture coarse; great contrast in elevation of subsegments . . . . . **E. granosa.**
  - Spines either very short with highly developed spinules, or long with very slightly developed spinules.
    - Body with broadly rounded hinder extremity.
      - Hinder half of body much smaller than front half, the change sudden . . . **E. carri.**
      - Hinder half of body gradually tapering and not strikingly different in the two halves **E. euspidata.**
    - Body with hinder extremity abruptly tapering to a blunt point . . . . . **E. flabellata.**
- Ordinary sized species with simple spines . . . . . **E. spinulosa.**

Body slender and long drawn out.
- Nearly uniform throughout.
  - Segments at least half as broad again as long. . . . . **E. simplex.**
  - Segments hardly broader than long . . . . . **E. tracta.**
- Delicately tapering so as to be less than half as broad at tail as in front . . . . . **E. anguilla.**

Euphoberia hystricosa sp. nov.

Pl. 33, figs. 1, 3.

Unfortunately but a small fragment of the single known specimen is preserved, but this is so characteristic as to leave no doubt of its relations. Seven adjoining segments from near the middle of the body appear on the small nodule, all of the same size and showing a dorsal aspect. The segments are about two and a half times broader than long, and the shorter anterior portion is considerably elevated and bears near its outer limit a boss which represents the base of a spine belonging to the subdorsal series; the spines themselves are broken off, but those of one of the lateral series appear, and are exceedingly large and formidable. They are very stout and very long, nearly as long as the entire breadth of the body and apparently depressed, forked a little beyond the middle, the forks only slightly divergent and subequal, lying in the same plane as the body of the spine, the anterior the longer, stouter and blunter, and scarcely bent forward from a continuation of the basal part of the spine. Besides this, there is at the base, apparently clearly separated in all instances from the great spine, but in close proximity to it, a slender spinule anterior and another posterior also lying in the same plane, but showing no signs of depression.

Length of the fragment, 46 mm.; of the single segments, 5.5 mm.; breadth of same, 14 mm.; length of spines, 13 mm.; width at base, 1.75 mm.; length of spinules, 3 mm.

The species closely resembles in general effect *Acantherpestes major*, but there are no pleurodorsal series of spines, and therefore it cannot fall into that genus. No species of Euphoberia at all resembles it, or can compare with it in size, excepting the European *E. ferox*, which differs entirely in the shape of the spines at base, and in lacking the anterior ridge upon which the subdorsal spines are mounted. The spines of this species closely resemble those of *Acantherpestes major*, and agree with them in size, but they differ in the great depth of the apical fork, as well as in minor points.

The nodule comes from Mazon Creek, Ill., and was sent to me for study by Mr. R. D. Lacoe, in whose collection it bears the number 1802ab.

Euphoberia armigera.

Pl. 34, figs. 2. 4, 8; pl. 35, fig. 3.

Euphoberia armigera Meek and Worthen, Amer. Journ. Sc., (2), XLVI, 25–26 (1868).

A specimen received from Mr. R. D. Lacoe (No. 1804cd, of his collection, fig. 3) from the Mazon Creek nodules, is nearly complete but appears to lack both extremities; thirty-five segments are preserved, showing a dorsal view of a sinuous body, the lateral spines of one side nearly complete, together with a few of the other side in front; these are slender, gently curved, and do not appear to show any spinules whatever, though there are here and there possible indications of them, not shown in the figure; the spines are, however, poorly preserved, and the absence of spinules may be looked upon as merely the accident of preservation. The body is not prominently ridged, and is flattened by preservation; no rugosity of the surface is noticeable. The anterior half is of nearly uniform size, scarcely tapering in front, the segments about twice as broad as long; the posterior half tapers very regularly to less than half the size of the middle, the segments shortening a little. The spines are about half as long as the greatest width of the body. No legs are visible.

Length of specimen, 75 mm.; greatest breadth, 4.25 mm.

Besides this I have seen nearly a dozen specimens, most of them received from Mr. R. D. Lacoe, but others from Mr. W. F. E. Gurley, Prof. J. S. Newberry and Mr. F. T. Bliss. None of these require special mention, excepting one of those received from Mr. Lacoe under the number 1804kl (fig. 8). This is a portion of the hinder end of the body of unusually large size, and containing about twenty-nine segments; one remarkable thing is the slight degree to which it tapers, the diminution in size being altogether confined to the last ten segments, half the diameter being lost in that distance. The segments are nearly twice as high as long, have the subsegments well distinguished, and show the texture of the surface, which appears to have been finely pitted with transversely arranged somewhat transverse punctures, shown as too circular in the figure (fig. 2). Along the middle line of the body and also next the under edge appear some perhaps wholly foreign textures, one of which is represented still further enlarged in fig. 4, which are serially arranged and may be mere mineral fillings of spine-scars. Nearly all the subdorsal spines are seen; they are well heeled, rather slender, arcuate, and pointed, considerably longer than the segments. Very many of the legs can be seen, and these are unusually short and stout and incurved; the enlarged figures show well their division into joints at different parts of the body, from which it would appear that the second joint was not elongated, and on this account I have very much doubted whether this specimen should not be separated from the others as a distinct species.

Length of fragment, 108 mm.

Euphoberia granosa.

Pl. 34, figs. 5, 6; pl. 36, fig. 2.

Euphoberia granosa Scudd., Mem. Bost. Soc. Nat. Hist., III, 168 (1882).

To this species I refer several specimens seen since the originals were described, which

are remarkable for their coarse sculpture, inequality of the subsegments, and general form of the segments, although some at least of them have spines which differ somewhat from those of the previous specimens, perhaps due, however, to their belonging to different longitudinal series.

One of them which is here figured (fig. 6) shows only about a dozen or fifteen segments from near the anterior end of the body, and is considerably larger than the largest specimens hitherto known. It is preserved upon the side and the spines seen at one edge are evidently those of the subdorsal series. The segments are about three times as broad as long, but the flattening of the body largely conceals the evident previous inequality of the subsegments; the surface is very coarsely granular (fig. 5). The spines are rather stout, very much shorter than the segments, curved backward, and show no sign of any anterior fine basal spinule, but instead a distant basal posterior spinule of similar coarseness as the main spine, but very low; these are not well shown on the plate as they can only be well made out by shifting the point of view. The legs are slender and nearly as long as the width of the body. The ventral plates are seen in part and are normal.

Length of fragment, 58 mm.; breadth, 10 mm.

The specimen comes from Mazon Creek, Ill., and was received from Mr. R. D. Lacoe, in whose collection it bears the number 1805 ij.

Another specimen, also received from Mr. Lacoe and bearing the number 1805mn, is of nearly equal size, preserved in a sinuate curve, lying upon its side, and showing similar parts; it is much more complete, showing almost the entire length of the animal, the head possibly and a portion of the tail certainly absent. About thirty-eight segments are present. It is of nearly uniform size throughout, except that it is slightly larger over a rather broad space in the middle, the front third about equal, and the posterior part considerably smaller, giving a contour unlike any before met with. The segments have the usual proportions and distinct heavy sculpture of the species, the granulations, however, somewhat exceptionally unequal and distant. Here also the spines of the subdorsal series are much as in the specimen last described, but do not show so clearly the posterior basal spinule, and also show no sign of any anterior one. The legs are slender, extended at full length, and evidently longer than the width of the body in advance of the widest part.

Length of fragment if extended, 95 mm.; greatest width, 9.5 mm.

Two other specimens also received from Mr. Lacoe, Nos. 1805kl and 1805h, of smaller size, also belong here; they show nothing peculiar excepting that each at its hinder extremity, which in one case is perfect, shows that the subdorsal spines at this extremity of the body were apparently simple but remarkably stout, short, and blunt; they are only twice as high as their basal breadth.

To this species I also refer doubtfully a specimen from Mazon Creek (fig. 2) sent me by Mr. Gurley, showing about twenty-four segments preserved on a side view with some of the legs. No spines are present and only a few places are at all characteristic. It is in any case a small specimen, measuring but 40 mm. in length, and 1.75 mm. in diameter. It is nearly equal throughout, tapering only a little toward the tail. The legs are 2 mm. long.

Euphoberia carri.

Euphoberia carri Scudd., Mem. Bost. Soc. Nat. Hist., III, 171 (1882).

A single additional specimen has come to hand, a large fragment containing all but the two ends of the body, stretched in a bent line, presenting a dorsal view of about thirty segments. As in the specimens already described, there is not only considerable diversity in the general size of the front and hinder half of the body, the front half being nearly double the width of the hinder, but the change is relatively rapid, falling upon a few segments near the middle, though this is not so pronounced as in those previously described. The segments are about three times as broad as long, with a slightly greater relative breadth on the front than on the hinder half of the body. The anterior spiniferous half of each segment is heavily ridged, while the posterior is nearly flat, though this condition is somewhat effaced by crushing in the middle of the body.

Only the basal bosses of the subdorsal series of spines can be seen and these are near together, but in many cases obscure. The lateral series is tolerably complete throughout upon both sides and shows these spines to have been tolerably stout, sharply pointed, a little curved and scarcely so long as the segments; where suitably turned they show an angle near the middle of the front contour, which is all that appears of a spinule, probably broken off; but a very considerable, straight, slender needle arises from behind the base of the main spine, in situations favorable for it to be seen, almost half as long as the main spine. No legs are preserved. The whole surface of the body is finely and evenly granulate.

Length of fragment, 63 mm.; greatest breadth, 9 mm.; least breadth, 5.5 mm.; length of spines, 2.5 mm.

Mazon Creek, Illinois. Museum of Columbia School of Mines, communicated by Dr. J. S. Newberry.

Euphoberia cuspidata sp. nov.

Pl. 34, figs. 3, 7.

A single specimen only is known of this species, the head end of which is obscure, and the other extremity broken off. About seventeen segments are shown, preserved in a straight line upon a side view. The body tapers forward a little on the three or four front segments and to a somewhat similar degree behind the twelfth or thirteenth segment, but the portion preserved is very nearly uniform. The surface is granulose as in *E. granosa*. The head is exceedingly vague, but appears to be large, to have a rounded front, and to droop. The body segments appear to be slightly selliform by the ridging of the anterior edge, and they bear, apparently on the posterior half of the segments, a row of superior spines (presumably on both sides). By the fracture of the stone, these spines are very obscure, but they appear to be short, stout and double, having an anterior erect prong, not higher than one-fifth of the thickness of the body, and an oblique, backward directed, posterior prong a little shorter and subtriangular. The legs are a little longer than the thickness of the body, laminate, the flat surface set obliquely (the edge being forward and outward), of nearly equal width until near the pointed tip, when they taper rapidly, the joints indistinguishable in this specimen.

Length of specimen, 36 mm.; breadth, 2.5 mm.; length of legs, 4 mm.; their basal breadth, 0.75 mm.

The species is distinguishable from the others by its short, double spines, its more than usually equal form, and by the shape of the segments, which are only about half as broad again as long. It seems to be most nearly related to *E. carri*, but altogether lacks the sudden attenuation of that species in the middle of the body. It is not unlike *E. granosa*, with which the texture of the body and the length of the segments agree, but the spines are very different and there is no such sudden contrast in elevation between the subsegments. The figure represents the legs as much too slender.

The specimen was sent me for study by Mr. R. D. Lacoe, in whose collection it bears the number 1814ab. It comes from Mazon Creek, Illinois.

Euphoberia spinulosa sp. nov.

Pl. 34, fig. 1; pl. 35, figs. 1, 4, 5; pl. 36, figs. 7, 8.

The single specimen upon which this species was first recognized is a nearly complete animal lying partly coiled on its side (Pl. 34, fig. 1) and showing the legs and a few spines. It is somewhat stout, tapering only a little in its posterior half and still less anteriorly, the specimen composed of about thirty-seven segments; the segments consist apparently (for they are crushed and obscure) of an anterior, shorter, elevated, domed portion, bearing spines, and a longer, lower and flat portion. In some places the ventral plates, two to each of the dorsal subsegments, can be seen, every alternate one bearing legs; that is, every ventral segment is broken into two,—an anterior larger, pediferous, and a posterior apodal subsegment, the division indicated by a slightly lower level of the apodal half. The main segments of the body are from two or two and a half to a little less than three times as broad as long, and the spines (of which only a few of the subdorsal ones can be seen) are perfectly simple, straight, slender and tapering, scarcely half as long as the width of the body. The legs are slender and tapering, slightly more than half as long as the width of the body. The head is completely obscured, being mingled with the legs toward which it is coiled, but the posterior end of the body is distinct, with a rounded rectangular hinder edge where in the last segment it suddenly comes to an end.

Estimated length of the specimen if uncoiled, 94 mm.; breadth in the middle, 6 mm.; at posterior extremity, 3.5 mm.; length of legs, 3.5 mm.; of spines, 2.75 mm.

The specimen lies on a piece of blue limestone forming the roof shale over the lower coal seam at Braidwood, Illinois, and was received for study from Mr. R. D. Lacoe, in whose collection it bears the number 1820a.

The species as based upon this specimen seems to differ from all I have seen in the simple character and delicacy of the spines, which have no basal thorn; the anterior elevated portion of the segments is also narrower in proportion to the rest than usual.

About a dozen other specimens later examined agree pretty well in their general characteristics with *E. granosa*, and in the form of the segments with *E. carri*, but differ from them, as from nearly all others, in the character of the armature, the spines being long and slender and entirely without basal or other secondary spinules, and are there-

fore regarded as belonging here. In this respect they agree apparently with *E. brownii* of England, with which indeed they may possibly prove identical, though they grow to a much larger size than any British specimens I have seen.

The most perfect example (figs. 4, 5) is preserved upon a side view, each half with a distinct and partial coil. The lateral termination of the dorsal and ventral scutes is visible throughout; and the large transverse spiracles are readily seen next the outer base of the legs, in the middle of the segments or with the anterior edge in the middle of the segments. The head shows little beyond its outline, and appears little larger than the segment behind it, with an inferior tapering prolongation; from a little below the middle of the front springs an antenna whose total length a little exceeds that of the head, interrupted in the middle, but apparently as a whole consisting of ten or eleven joints which are oval and subequal, more than half as long again as broad, and slightly larger apically than basally, the terminal joint smaller than the others. The body is largest in the middle and subequal in more than the middle half, tapering about equally and very gently at each extremity. As thus preserved, upon a side view, showing only one half of their surface, the dorsal scutes are of about equal length and breadth, and appear to be composed of a larger anterior and shorter but higher posterior section, upon the latter of which the straight, simple, delicate spines shorter than the segments are mounted. The legs are exceptionally short and stout, and blunt tipped, hardly tapering; they are about as long as the segments.

Length if uncoiled, 84 mm.; height in middle, 4.5 mm.; length of segments, 2.75 mm.; of spines, 2 mm.; of legs, 2.5 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1820cd.

One of the largest specimens belonging to this species (Pl. 35, fig. 1) is also preserved upon a side view coiled into a semicircle. The ventral scutes here look as if formed of a collection of transverse straps, three or four to each scute, with a finely granular surface, but the dorsal scutes are less perfectly preserved, though when clear differ in no way from those of the typical specimen; the spines at the front end of the body are, however, relatively coarser and the legs seem relatively longer. The specimen measures 130 mm. in length, and 9 mm. in middle height, tapering as in the preceding toward either end but perhaps over a longer region. The specimen is in the collection of Columbia College, whence I received it through the courtesy of Prof. J. S. Newberry.

Another specimen (Pl. 36, fig. 8) shows the same view of the front half of an animal stretched out straight, and is interesting principally from its preserving one of the antennae attached to the middle of the front of the head (fig. 7); this is apparently not complete, a little shorter than the head and composed of about seven joints, some of them obscure, but where best preserved cylindrical and half as long again as broad; it tapers a little. The distinction between the anterior and posterior sections of the body-segments is greater than usual, and where the surface is clearly seen it is distinctly and rather coarsely granulate; the stigmata are very distinct, and as in the previous specimens, but the legs are vague. It comes from Mazon Creek, Ill., and bears the number 1820cf, in Mr. Lacoe's collection.

Other specimens, some received from Mr. Lacoe, others from Mr. Gurley, do not appear to add much to what these have told us. One, however, No. 1820gh, of Mr. Lacoe,

is a young specimen, and here the spines appear to be erect with no backward sweep and to be nearly or quite as long as the width of the body; only a dozen segments are preserved and the specimen, very imperfect, is only 17 mm. long and 1.75 mm. in diameter.

Euphoberia simplex sp. nov.

Pl. 35, figs. 2, 6, 7.

A couple of specimens of spined Archipolypoda differ so much from the others I have described, that they seem better separated from them. By their slender forms they agree best with the two species which follow, while in their size and armature they agree better with most of those that precede.

The first and best specimen (fig. 2) shows the whole of a myriapod extended with a gently sinuate curve; it presents a lateral aspect. The head is a little larger than the immediately succeeding segment, but is very poorly preserved, and shows no appendages. The segments of the body are thirty-seven in number, increase rather rapidly in size on the anterior six, the size then attained being retained up to the third or fourth before the hinder end when they taper similarly, the last segment being bluntly rounded and about as large as the head; excepting where tapering, the segments are a little less than twice as broad as long, and are separable into a shorter anterior and a longer and more elevated posterior subsegment, at the anterior part of the latter of which the spines are seated. These are arranged as usual in the genus, and the subdorsal series consists of nearly simple, short and pointed, arcuate spines, barely or not half so long as the segments, with a posterior basal spinule arising faintly from a sort of heel to the spine, often very inconspicuous and not shown on the plate; in texture, the upper surface appears to be finely granulated, while the lower plates show a fine punctuation, the punctae transversely elongated. The legs are very well preserved, in many places showing well the division into joints and the median longitudinal carina; the second joint is usually just about as long as the subequal remaining three; they are strongly compressed laterally, and most of the tapering occurs on the apical joint; their surface is smooth but not polished.

Length, 91 mm.; breadth in middle, 4.5 mm.; length of middle legs, 3.75 mm.; of longest spines, 2 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1812ab.

A second less perfect but interesting specimen from the same place (fig. 7) is similarly preserved on the stone but with the hinder end drooping and possibly not quite complete. The head is better preserved than in the preceding specimen, much larger than the immediately succeeding segments, well rounded, a little longer than broad, and shows a few obscure antennal joints (fig. 6); they are only three or four in number, subequal in length, but narrowing slightly, and all together not more than half as long as the head. The body is subequal almost throughout, scarcely showing any signs of tapering in front, while the specimen is too imperfect behind to determine that point. There are about thirty-three segments which are only about half as broad again as long. No spines can be certainly made out, but nearly all the legs are preserved, though ob-

scurely, and where preserved do not always show the longitudinal carina on adjacent segments; legs are found at entirely equal intervals up to the head, but the state of preservation of this general region does not permit further statement; the legs are a little shorter than the width of the body.

Length, 51 mm.; breadth, 2.75 mm.; length of legs, 2.4 mm.; of antennae 1.75 mm.

Mazon Creek, Ill. Mr. W. F. E. Gurley.

The species is peculiar for its slender form and relatively long segments combined with short sharply pointed spines. In general appearance, except for its slenderness and general form, it reminds one most of *E. carri*.

Euphoberia tracta sp. nov.

Pl. 36, figs. 1, 4–6.

The first specimen seen (fig. 1) is only tolerably well preserved, shows both obverse and reverse, and exhibits a lateral view of the greater part of the creature from the head backward over about thirty-four segments. The body is gently curved, the back convex, and near the head end more strongly arched, exceedingly long and slender, of nearly uniform size throughout, there being no sign of tapering anteriorly, and it is barely perceptible on the posterior fourth preserved. The head is larger than the segments behind, and droops considerably, the larger size being indicated by the amount of this droop, since the top of the head is continuous with the upper surface of the body; it is well rounded in front, but nothing can be made of any appendages. Unfortunately also none of the spines are preserved, and the only indication of their presence is in occasional pits, especially at the anterior end. The segments are unusually long, bringing the legs of succeeding pairs much farther apart than usual. Excepting in the anterior part of the body, they are of about equal length and breadth,—a feature which at once distinguishes this species from any other; the anterior part of the segments is narrowly ridged, and across the middle is a less prominent and more rounded transverse elevation dividing each segment into two equal subsegments. This has not been made to appear in the figure. In places where best preserved the surface of the segments shows a very delicate granulation. The legs are, as stated, far apart, a little longer than the width of the narrow body, slender, tapering regularly and pointed. They show slight or no signs of any unusual basal expansion, and their joints are indistinguishable.

Length of body, 46 mm.; width of same, 1.6 mm.; length of legs, 2.5 mm.; their basal width, 0.3 mm.

The specimen comes from Mazon Creek, Ill., and is numbered 1838ab, in the collection of Mr. R. D. Lacoe, from whom I received it.

The second specimen (fig. 5) is in a similar state of preservation, and was not seen until the preceding was described. It shows both obverse and reverse and represents the lateral view of the entire animal, if the tail end is complete, and though difficult to determine by its obscurity in certain parts, appears to be composed of about thirty-five segments behind the head. The body is long and slender, tapering very inconsiderably in its posterior half. The head appears to be still partly buried in the stone, and consequently does not show its size or form, but it evidently droops very much below the lower level of

the body. No spines are preserved anywhere, and only slight indications of their insertion are apparent. The segments are obscure throughout, excepting near the head, and therefore could not be enumerated, but for the legs. As in the previous specimen, they appear to be generally of about equal length and breadth, but next the head they are broader than long. The division into two parts, as shown in the other specimen, is obscured here, excepting next the head where it is identical. The legs are as in the other specimen, except in being possibly a little longer and in showing some basal expansion.

Length of body (if straightened), 40 mm.; middle width of same, 1.5 mm.; length of legs, 2.8 mm.; their basal width, 0.3 mm.

The specimen comes from the same place, and bears the number 1838cd, in Mr. Lacoe's collection.

A third specimen (fig. 4) seen, together with the following, after the preceding descriptions had been written, shows a lateral view of a slightly arcuate animal, nearly the whole of which is preserved, although almost wholly destitute of appendages. The body is thus seen to be of nearly equal size thoughout, scarcely tapering on the first three or four segments and in the posterior fourth, composed of forty-two subquadrate segments, besides the head; the latter is a little broader and larger than the segment behind, well rounded but shows no appendages. The segments are everywhere similar, about a third or a fourth broader than long and show a division into two subsegments by a median or antemedian tranverse sulcation and a slight difference in elevation of the two subsegments, the anterior being slightly the higher; the signs of spines are slight, but occasionally a simple, arcuate, very short spinule rises above the dorsal outline. The legs are almost entirely obliterated, but a few at either extremity show that they are as long as the width of the body or even longer, and very slender.

Length of body (if straightened), 45 mm.; middle width of same, 1.6 mm.; anterior width, 1.2 mm.; length of anterior legs, 1.5 mm.

The specimen comes from Mazon Creek, Ill., and was received from Mr. R. D. Lacoe, in whose collection it bears the number 1838gh.

A fourth specimen (fig. 6) shows a scarcely arcuate body of a specimen slightly larger than the last but not so fully preserved, both ends being lost. About thirty-six segments are seen, slightly broader than long, but in general they show very little structure; it would seem, however, as if besides the median sulcation between the subsegments, each of the latter had its own submedian transverse sulcation much sharper and slighter than the other; the surface was apparently smooth; no signs of spines appear except a lateral series indicated at one extremity by very deep circular pits at one margin, presumably the anterior, of each segment. Legs are seen all along the lower margin of the body, though by no means always perfect; when complete they are somewhat longer than the width of the body, very slender, and delicately tapering.

Length of the fragment, 52 mm.; breadth in middle, 2 mm.

This specimen also comes from Mazon Creek, Ill., and from Mr. Lacoe, and bears the number 1838ef.

A fifth specimen is a curious one; it represents apparently a single specimen, but it is bent abruptly upon itself twice, so as to be broken or apparently broken into three

nearly equal parts, lying one above the other, the upper and lower parallel, the middle and longer piece, really the anterior third, a little oblique, crossing one end of one of the others. The great length and slenderness of the specimen with the subquadrate form of the segments leave no room to doubt that it belongs here, but it shows very little, for the head is unprovided with appendages, and only slight indications of spines, quite as in the other specimens, appear. Some parts display the legs fairly well, showing that they were very slender and tapering, considerably longer than the breadth of their segments. The body appears to have been largest near the base of the anterior third and to have tapered very slightly in either direction, the hinder end quite blunt. If it is not broken, but the disconnected parts are united beneath the present exposed surface of the stone, its total length must have been fully a decimeter; if broken and all parts are seen it would still be 9 centimetres long, while its greatest breadth is 2.5 mm., and at the hinder extremity 1.75 mm.

The specimen comes from Mazon Creek, Ill., and was received from Mr. R. D. Lacoe, in whose collection it bears the number 1838ij.

Another specimen has been received from Mr. W. F. E. Gurley from the same locality, but is exceedingly imperfect; it is apparently a young specimen, being if uncoiled only 40 mm. long. It is too poor to measure the breadth at any point, but it appears to have been equally slender with the others.

The species is remarkable for its nearly uniform and slender body, the great length of the segments as compared with the width of the body, the slenderness of the legs, and the unusual distance apart of consecutive pairs.

Euphoberia sp.

Mr. R. D. Lacoe has sent me a straight fragment of a Euphoberia, composed of about fifteen or sixteen similar and equal segments from what is apparently about the middle of the body, but which is too imperfectly preserved to determine the species, though it perhaps represents *E. tracta* or *E. simplex*. It would not be worth mentioning but for the appearance it presents of being covered above with a mat of flowing hairs, here appressed to the surface. The segments are about half as broad again as long, and their surface finely granulate. The total length of the fragment is 26 mm.; it comes from Mazon Creek, Ill., and is marked 1839a, by Mr. Lacoe.

Euphoberia anguilla.

Pl. 36, fig. 3.

Euphoberia anguilla Scudd., Mem. Bost. Soc. Nat. Hist., III, 177, Pl. 12, fig. 20 (1882).

An additional specimen (fig. 3) has been found, but it adds little to our previous meagre knowledge. It is nearly complete, however, though the head end is altogether obscure. It lies in an arcuate position upon the stone, the dorsal parts convex, and the legs drooping from the under surface. The head is very obscure, but apparently agrees with what is seen in the original specimen, and, as there, no appendages are visible. The body is largest in the middle of the anterior half and tapers very gently in each direction, the tail being about half as wide as the broadest portion, which is not so nar-

rowly confined as in the specimen before found; the segments vary in their proportions very much as in the original, though they appear to be relatively shorter next the hinder end. The legs are poorly preserved, but can be seen through all but the front end of the body to be shorter than the width of the body, especially in its widest portion, and to be rather stout, slightly tapering and blunt tipped. No spines are clearly seen, but their presence on the subdorsal region is indicated by obscure marks, which in no way differ from the few seen in the type. The specimen is about 53 mm. long and comes from Mazon Creek, Morris, Ill., where it was obtained by Mr. F. T. Bliss. It bears the number 131 in my collection.

Still another specimen of what appears to be this species has been sent me by Mr. R. D. Lacoe. Both faces of the nodule show the specimen about equally well or rather ill. It is indeed so faint that no attempt has been made to have it drawn. Like the original it is preserved on a dorsal view in a curved position, the front two-thirds pretty strongly bowed, the hinder third bent at right angles to the part in front and curved or roundly bent in the same sense. The whole animal appears to be preserved and it differs from the type only in tapering a little more rapidly and in having the posterior extremity extended almost to a point. If extended its length would be about 35 mm.; its breadth at greatest behind the head, 2.5 mm.; and in the middle of the body, 1.75 mm. The segments are too indistinct in many parts of the body to be counted, so that the total number cannot be compared with that of the type, but just behind the head the segments appear to be just about twice as broad as long, and in the middle of the hinder half they are proportionally but little longer than in front. The tapering of the body is almost entirely confined to the hinder half, and at the extreme tip the body is less than 0.25 mm. broad. Nothing can be told from this specimen any more than from the first known concerning the structure of the spines or legs, unless certain marks at the sides of this, near the middle, indicate legs; these would then be exceedingly slender and fully as long as the width of the body.

Mazon Creek, Ill., nodules. No. 1807cd.

Family Archiulidae Scudder.

Archiulus Scudder.

Several species are now known to me from North America, besides those here described which are somewhat problematical from the nature of their entombment. Others from the sigillarian stumps of Nova Scotia will be described on another occasion.

Archiulus? glomeratus sp. nov.

Pl. 37, figs. 2, 3.

A closely coiled, moderately large galley-worm (fig. 2) is doubtfully referred to this genus, though much larger than any heretofore found, because its well preserved segments show no sign of any division into frustra and no indication of spines or any longitudinal series of prominences. Eighteen or nineteen segments are preserved, all but

four or five of them very well,—at least the dorsal scutes. These consist of simple plates with well rounded lower edges which apparently extend beyond the lateral limits of the body proper (to judge by the transverse curving ridges generally seen above their termination), about twice as broad as their greatest (superior) length, with indications of some thickening of the anterior and posterior margins, preceded by a more or less distinct and extensive transverse furrow. No definite signs of the ventral scutes can be seen and they are apparently covered by the presumed lateral expansion of the dorsal scutes which on a side view would conceal them. The legs are seen in several places, but too obscurely and intermingled to say more of them than that they appear to be certainly very stout and long and longitudinally ridged. Neither extremity of the body is seen and there is no apparent sign of any tapering.

Length of specimen if uncoiled, 43 mm.; length of single segments, 2.5 mm.; breadth of same, 5.5 mm.; breadth of legs near middle, 0.75 mm.

The specimen occurs in a nodule from Mazon Creek, Ill., and was collected by Mr. J. C. Carr, to whom I owe the opportunity of studying it. It has since been secured by Mr. Lacoe, in whose collection it bears the number 1823ab.

Here also I am inclined to place a similarly coiled but much smaller specimen (fig. 3) from the same locality, preserved in a small nodule sent me by Mr. R. D. Lacoe and bearing the number 1823cd. It is rather obscure and shows little more than the dorsal scutes seen on a side view with no sign of spines or legs or frustra. About forty-two segments are represented and all are of nearly the same size and in their relative proportions closely resemble the larger specimen before described. The texture of the surface is very finely granular, almost smooth. If uncoiled, the creature (imperfect) would be about 36 mm. long; its width is 2.5 mm.

Archiulus? sp.

Pl. 37, fig. 1.

A species of myriapod apparently belonging to this genus but very obscurely preserved on black shale amid a mass of vegetable débris, especially fern leaves, was sent me by Mr. R. D. Lacoe from the Malden Mine, Kittanning coal, Kanawha Co., W. Va., and bears in his collection the number 1810a. It represents an openly coiled body, apparently nearly complete as to length, about 85 mm. long, composed of from forty to fifty segments very obscurely defined. The body is largest at what is taken to be the head end, tapers rapidly to the head and very gradually to the tail end at the edge of the stone. Generally speaking the segments are about twice or a little more than twice as broad as long, and the surface is generally covered with an exceedingly delicate and uniform striation transverse to the body, and in some places at the head end also longitudinally; although not detected elsewhere on the stone, it is suspected to be extraneous to the fossil.

Xylobius Dawson.

This genus, peculiar for the frustrate dorsal scutes of the body, originally described from the sigillarian stumps of Nova Scotia, is now somewhat widely known, occurring

as it does in Great Britain and, as will be seen by the following descriptions, from the carboniferous deposits of Mazon Creek, Ill.

Xylobius frustulentus sp. nov.

Pl 37, figs. 4-6.

This is a small species and represented by specimens closely resembling in general appearance our smaller species of Iulus from temperate regions. One is preserved on a side view (fig. 5), strongly curved like a fish hook, and is apparently complete, though both ends are rather obscure. It is long and very slender, almost equal, tapering scarcely in the least at either end and composed of alternately longer and shorter segments, as shown in fig. 6; the number cannot be determined from the obscurity of parts of the body, but they would appear to number all told more than fifty. The larger ones are about three, the smaller about four times as broad as long. The frustra are the same on both, separated from each other by delicate incised lines, which are a little sinuous as well as slightly oblique; they are very narrow, narrower than on any known species, being eight or ten times longer than broad. The legs are delicate, slender, cylindrical, a little shorter than the width of the body, the joints indeterminate.

Length of the body, 33 mm.; width of same, 1.75 mm.; length of legs, 1.45 mm.

This specimen, which comes from Mazon Creek, was received from Mr. R. D. Lacoe, and is numbered 1842ab, in his cabinet.

The second specimen (fig. 4), sent me after the preceding description was prepared, is similarly preserved in a somewhat semicircular curve; as there, both ends are obscure and probably neither of them is complete. It is long and slender, nearly equal but slightly tapering on the posterior half and anterior fifth, and not so clearly composed as there of alternate longer and shorter segments, the shorter, in the greater part of the body at least, appearing more as mere interspaces and showing no sign of division into frustra, which are perfectly evident and exactly as in the other specimen in the shorter segments. The shorter segments have more the appearance of being originally formed of a less dense integument than the larger ones, and as being here folded or compressed; in this way only can the structure of the two specimens — which agree in all other respects — be made to accord sufficiently to consider them the same species. The number of segments, counting only the larger ones, are twenty-nine, and they have the same form and proportions as in the other specimens, with exactly similar frustra. The legs are of similar delicacy and length, but, as there, with indeterminate joints.

Length of body, 31 mm.; width of same, 2.2 mm.; length of legs, 1.75 mm.

This specimen was obtained at Mazon Creek, and was received from Mr. J. C. Carr, but is now in Mr. Lacoe's collection under the number 1842cd.

Still another specimen from the same place has been more recently sent me by Mr. W. F. E. Gurley. It is in better condition than the others, curled much as they, and shows all but the very head and hinder extremity; probably not half a dozen segments are lacking; forty-one appear. These are alternately longer and shorter, one about one-half longer than the other, each with its own independent arching; the whole of a pair of segments as thus constituted when seen on a side view, is about two-thirds as long

as high and is traversed longitudinally by fine lines breaking it up into frustra of exceeding slenderness, perhaps eight or ten times longer than broad. The legs are exceedingly slender, finely tapering to a delicate point, and about as long as the width of the body.

Length if extended, 44 mm.; breadth, 2.25 mm.

The species is mainly peculiar for the exceedingly narrow frustra, but also for the alternation of longer and shorter segments which appears wherever two adjoining segments are clearly defined. It bears certain resemblances to the interesting *Kampecaris forfarensis* Page, so carefully described and figured by Mr. Peach of the Geological Survey of Scotland; more indeed than to any myriapod yet described from this continent. But the smaller segments are much less important than there, the feet are much slenderer and Mr. Peach makes no mention whatever of anything akin to frustra. Our own species is represented by specimens far less perfect than his and does not admit of a really satisfactory comparison.

Xylobius mazonus.

Pl. 37, figs. 7–11.

Xylobius mazonus Scudd., Zittel, Handb. d. Palaeont., I, II, 730, fig. 902b (1885).

The first specimen of this species which came under my notice was received from Mr. Lacoe with the number 1809ab, and was interesting from being the first myriapod seen from Mazon Creek in which the segments were broken into frustra, and much larger than other species of the genus, found heretofore only in the sigillarian stumps of Nova Scotia. This specimen (fig. 7) is preserved on a side view, and shows a gently arched body, bent a little behind the head; excepting near the extremities, which taper considerably for half a dozen segments (fig. 9), the body is of nearly uniform width; it is complete, and composed of numerous very short segments, obscure in places but apparently numbering about fifty. The form of the body and its general appearance at first recall the commoner Euphoberiae of these beds, but a closer examination soon shows considerable differences. Spines are wanting, the extremely short and broad segments extend the whole width of the body and are broken regularly into frustra; the legs are very delicate and not very long, and the head is not larger than the segment behind it. The segments are about six times as broad as long and the frustra unusually narrow, being fully four times as long (equal to the width of the segment) as broad, as shown in the enlarged sketch (fig. 8) of two or three adjoining segments a little in front of the middle of the body. The legs are very slender, and apparently cylindrical, but their full length shows only at the hinder extremity of the body where they equal its diminished diameter. The specimen is 61 mm. long; 5.5 mm. broad in the middle; 2.75 mm. broad at the head end; the longest legs at the posterior end are about 4 mm. long.

The second specimen (figs. 10–11) is more interesting on account of its perfection. It was also received from Mr. Lacoe and bears the number 1809cd, in his collection. It also shows a side view, gently arched, especially toward the head end, which is apparently complete though obscure, while the hinder end is partly concealed under stone,

and may extend beyond the limits of the enclosing nodule. The body is of nearly uniform width, but tapers forward a very little on the first eight or nine segments and toward the posterior end. The segments preserved are forty in number, and are of about the same proportion as in the other specimen. From its better preservation, however, it shows clearly, what the other shows but vaguely, the exact form of the segments; the body was plainly cylindrical or nearly so, and the anterior and posterior border of each segment was thickened to form together an elevated, more or less rounded band, together a little more than twice as broad as the intermediate, lower and more flattened interspace covering the most of the segment; the anterior thickening occupies twice as much of the band as the posterior; the sutures of the frustra cross the entire segment, including the band, both anteriorly and posteriorly; the frustra are separated and marked off by slight raised lines, running with a slight obliquity and are of the same proportion as in the other specimen. The head shows no peculiarities, as it merely ends in a bluntly rounded curve, with no visible appendages and is altogether very obscure. The legs are delicate, slender, cylindrical, pointed, and unless in the proportionate lengths of the joints, which cannot be determined, in all respects like those of a modern Iulus; they are nearly as long as the width of the body.

This specimen is also of special interest from the fact that its excellent preservation ensures seeing any spines which might project beyond the body, and which do not exist. On one of the stones, however, there may be seen on most of the segments a minute wart or tubercle centrally placed, forming a pleurodorsal row apparently about midway between the middle of the sides and the middle of the back, similar therefore to some obscure indications of the same sort on other species of Xylobius. It is interesting also as showing clearly the lower edges of some of the dorsal shields next the present lower edge of the fossil, showing that here the ventral scutes must be much narrower than the dorsal.

The length of the specimen is 45 mm.; its breadth in the middle, 4.5 mm.; at the head end, 4 mm.; length of legs, 4 mm.; their greatest breadth, 0.08 mm.

Both the specimens are from Mazon Creek, Ill.

The species differs from any known by its much larger size, the narrowness of its frustra, and the strap-like character of its sutural prominences, which do not fall gradually to the level of the lower part of the segment forming a more or less striking selliform curve, but abruptly.

EXPLANATION OF THE PLATES.

PLATE 33.

Figs. 1 and 3 are by Mrs. Katherine Peirson Ramsay; figs. 2 and 4 by J. H. Emerton.

Fig. 1. *Euphoberia hystricosa* $\frac{1}{1}$.
Fig. 2. *Acantherpestes inequalis* $\frac{2}{1}$.
Fig. 3. *Euphoberia hystricosa* $\frac{1}{1}$; reverse of fig. 1.
Fig. 4. *Acantherpestes inequalis* $\frac{2}{1}$.

PLATE 34.

Figs. 1, 3 and 7 are by Mrs. Katherine Peirson Ramsay; the others by J. H. Emerton.

Fig. 1. *Euphoberia spinulosa* $\frac{2}{1}$.
Fig. 2. *Euphoberia armigera;* a portion of the integument of one of the neighboring segments of fig. 8, further enlarged.

Fig. 3. *Euphoberia cuspidata* $\frac{4}{1}$; the anterior extremity only.
Fig. 4. *Euphoberia armigera;* one of the peculiar structures of the opposite segment of fig. 8, further enlarged.
Fig. 5. *Euphoberia granosa;* a portion of the integument of one of the neighboring segments of fig. 6, further enlarged.
Fig. 6. *Euphoberia granosa* $\frac{2}{1}$.
Fig. 7. *Euphoberia cuspidata* $\frac{2}{1}$.
Fig. 8. *Euphoberia armigera* $\frac{2}{1}$; several of the legs are still further enlarged and placed opposite their position on the body.

PLATE 35.

Figs. 1, 2, 4 and 5 are by J. H. Emerton; figs. 3 and 7 by Mrs. Katherine Peirson Ramsay; fig. 6 by J. Henry Blake.
Fig. 1. *Euphoberia spinulosa* $\frac{1}{1}$.
Fig. 2. *Euphoberia simplex* $\frac{2}{1}$; some of the legs still further enlarged are placed opposite their position relative to the body.
Fig. 3. *Euphoberia armigera* $\frac{2}{1}$.
Fig. 4. *Euphoberia spinulosa* $\frac{2}{1}$.
Fig. 5. *The same* $\frac{2}{1}$; the head; from the reverse of fig. 4.
Fig. 6. *Euphoberia simplex* $\frac{2}{1}$; the head and antenna of fig. 7.
Fig. 7. *The same* $\frac{1}{1}$; the entire animal.

PLATE 36.

Figs. 1, 2, 3, and 5 are by Mrs. Katherine Peirson Ramsay; the others by J. H. Emerton.
Fig. 1 *Euphoberia tracta* $\frac{3}{1}$.
Fig. 2. *Euphoberia granosa* $\frac{3}{1}$.
Fig. 3. *Euphoberia anguilla* $\frac{2}{1}$.
Fig. 4. *Euphoberia tracta* $\frac{2}{1}$.
Fig. 5. *The same* $\frac{4}{1}$.
Fig. 6. *The same* $\frac{2}{1}$.
Fig. 7. *Euphoberia spinulosa;* the antenna of fig. 8, still further enlarged.
Fig. 8. *The same* $\frac{2}{1}$.

PLATE 37.

Figs. 1–5, 7 and 9–11 are by Mrs. Katherine Peirson Ramsay; figs. 6 and 8 by J. Henry Blake.
Fig. 1. *Archiulus* sp $\frac{2}{1}$.
Fig. 2. *Archiulus glomeratus* $\frac{2}{1}$.
Fig. 3. *The same* $\frac{3}{1}$.
Fig. 4. *Xylobius frustulentus* $\frac{3}{1}$.
Fig. 5. *The same* $\frac{2}{1}$.
Fig. 6. *The same* $\frac{6}{1}$; a couple of segments from near the middle of the body of fig. 5.
Fig. 7. *Xylobius mazonus* $\frac{2}{1}$.
Fig. 8. *The same* $\frac{4}{1}$; three segments from the middle of the front half of the body of fig. 7.
Fig. 9 *The same* $\frac{4}{1}$; a few of the terminal segments of fig. 7.
Fig. 10. *The same* $\frac{3}{1}$.
Fig. 11. *The same* $\frac{3}{1}$; reverse of fig. 10.

PLATE 38.

All the drawings are by J. H. Emerton.
Fig. 1. *Ilyodes divisa* $_1$.
Fig. 2. *Ilyodes elongata* $\frac{2}{1}$.
Fig. 3. *Latzelia primordialis* $\frac{2}{1}$.
Fig. 4. *Palenarthrus impressus* $\frac{2}{1}$.
Fig. 5. *Eileticus anthracinus* $\frac{2}{1}$.
Fig. 6. *Eileticus aequalis* $\frac{2}{1}$.
Fig. 7. *The same* $\frac{2}{1}$; side view of fig. 6.
Fig. 8. *The same* $\frac{2}{1}$; reverse of fig. 6.
Fig. 9. *The same* $\frac{2}{1}$.

SUMMARY LIST OF THE KNOWN PALEOZOIC MYRIAPODA OF NORTH AMERICA.

PROTOSYNGNATHA.

1. Palaeocampa anthrax Meek and Worthen. Mazon Creek, Ill.

CHILOPODA.

Gerascutigeridae.

2. Latzelia primordialis Scudd. Mazon Creek, Ill.

Eoscolopendridae.

3. Eileticus anthracinus Scudd. Mazon Creek, Ill.
4. Eileticus aequalis Scudd. Mazon Creek, Ill.
5. Palenarthrus impressus Scudd. Mazon Creek, Ill.
6. Ilyodes divisa Scudd. Mazon Creek, Ill.
7. Ilyodes elongata Scudd. Mazon Creek, Ill.

ARCHIPOLYPODA.

Euphoberidae.

8. Acantherpestes major Meek and Worthen. Mazon Creek, Ill.
9. Acantherpestes inequalis Scudd. Mazon Creek, Ill.
10. Euphoberia hystricosa Scudd. Mazon Creek, Ill.
11. Euphoberia horrida Scudd. Mazon Creek, Ill.
12. Euphoberia armigera Meek and Worthen. Mazon Creek, Ill.
13. Euphoberia granosa Scudd. Mazon Creek, Ill.
14. Euphoberia carri Scudd. Mazon Creek, Ill.
15. Euphoberia cuspidata Scudd. Mazon Creek, Ill.
16. Euphoberia flabellata Scudd. Mazon Creek, Ill.
17. Euphoberia spinulosa Scudd. Mazon Creek and Braidwood, Ill.
18. Euphoberia simplex Scudd. Mazon Creek, Ill.
19. Euphoberia tracta Scudd. Mazon Creek, Ill.
20. Euphoberia anguilla Scudd. Mazon Creek, Ill.
21. Amynilyspes wortheni Scudd. Mazon Creek, Ill.

Archiulidae.

22. Archiulus xylobioides Scudd. Joggins, Nova Scotia.
23. Archiulus glomeratus Scudd. Mazon Creek, Ill.
24. Archiulus sp. Malden Mine, W. Va.
25. Xylobius sigillariae Daws. Joggins, Nova Scotia.
26. Xylobius similis Scudd. Joggins, Nova Scotia.
27. Xylobius fractus Scudd. Joggins, Nova Scotia.
28. Xylobius dawsoni Scudd. Joggins, Nova Scotia.
29. Xylobius frustulentus Scudd. Mazon Creek, Ill.
30. Xylobius mazonus Scudd. Mazon Creek, Ill.

XI. Illustrations of the Carboniferous Arachnida of North America, of the orders Anthracomarti and Pedipalpi.

By Samuel H. Scudder.

Read May 7, 1890.

THE present paper contains a discussion of all the carboniferous Arachnida of America, excepting Arthrolycosa, of which Mr. C. E. Beecher has lately given a fuller and more correct account than we have had before, and the scorpions, which will be treated on a future occasion. The descriptions of the previously known species are more detailed than at first, other new forms are added, and illustrations are given of all, except of *Architarbus rotundatum*, previously figured; with that exception it is the first attempt to figure the American forms in these groups. It should be added, however, that since these illustrations were prepared, further material has come to my hand, mostly from the rich collections of Mr. Lacoe and of Mr. Gurley, which may still further extend the list, but I have been obliged to leave them for another occasion.

Order ANTHRACOMARTI Karsch.

Body somewhat depressed, the cephalothorax and abdomen distinctly separable. Cephalothorax usually made up in large part of more or less wedge-shaped pedigerous segments, the arrangement of which corresponds to that of the coxae. Abdomen forming a single mass and composed of from four to nine distinct joints. Palpi not much longer than the legs and simply terminated.

This group, the only extinct order of Arachnida, was established by Karsch for some interesting carboniferous forms of somewhat obscure relations allied to the Phrynidae and Phalangidae, but very distinct from either of them. Its position seems to be between the Chelonethi and the Pedipalpi, to the latter of which it bears perhaps the closest relations. The Anthracomarti were the most varied in structure and, with the possible exception of the scorpions, the most abundant in species of the carboniferous Arachnida, and being unknown after that period they may be considered the most characteristic of paleozoic Arachnida. The forms here considered belong to two distinct families.

Family Poliocheridae Scudder.

Cephalothorax quadrate, not much smaller than the abdomen. Coxae radiating apparently from a median line. Abdomen rounded, of equal breadth with the cephalothorax, with very indistinct or no longitudinal sculpturing, composed of only four segments, of which the basal is very short and the others of equal length. No abdominal appendages.

A single genus and species are known, confined to North America.

Poliochera Scudder (πολιός, χείρ)

Poliochera Scudd., Proc. Amer. Acad. Arts Sc. xx, 16 (1884).

Cephalothorax quadrate, a little longer than broad, the front square, the sides nearly and the posterior border quite straight, the surface flat. Abdomen rounded subquadrate, a little longer than broad, its base completely sessile, as broad as the cephalothorax, the sides and extremity convex and with a continuous curve, the surface flat and on the same plane as the cephalothorax, the first segment short, the others large and equal, the transverse sutures straight. Legs stout, depressed, moderately long.

This very anomalous arachnid, the position of which seems to lie near the Architarboidae, must be referred to a distinct family as given above. It would seem not improbable that Kušta's genus Scudderia (name preoccupied in Orthoptera, — Stål, 1873) is nearly allied to this.

Poliochera punctulata.

Pl. 39, figs. 2, 6.

Poliochera punctulata Scudd., Proc. Amer. Acad. Arts Sc. xx, 16 (1884).

The front border of the cephalothorax is a little elevated, and behind it, extending nearly to the middle, a very broad, very shallow, transverse depression; there is also an equally slight but small central depression, but all of these scarcely affect the extreme flatness of the whole field which is shared also by the abdomen; both cephalothorax and abdomen are regularly and deeply punctate, as shown in fig. 6, excepting on the brief first abdominal segment which is only punctate along its hinder edge, and excepting also, as in the figure, in the division lines of the segments; the punctuation is perhaps a very little heavier on the cephalothorax than on the abdomen. The abdomen is also marked by slight straight lateral ridges, dividing the segments into three nearly equal parts which are only noticeable on the front half of the segments, but can be traced throughout; a moderately narrow and slightly elevated rounded bounding ridge seems to follow the entire rim of the abdomen. The legs are stout or at least all but the front pair, and all are long though none are preserved for their entire length; the basal joints of all of them are short, stout and quadrate, those of the front pair about half as stout as the others, and those of the third pair the stoutest of all; the joint beyond is long and only a little more than half as broad as the basal joint, those of the different legs of about equal length with each other and nearly as long as the width of the cephalothorax; the third

joints are all broken in the specimen, but on some of the legs at least were apparently about as long as the second joints; all the joints are flattened and punctate like the body, but not so deeply. The front pair of legs is about two-thirds as stout as the others and a little shorter.

Length of body, 15 mm.; cephalothorax, 6 mm.; first abdominal segment, 0.8 mm.; second, 2.3 mm.; width of cephalothorax posteriorly, 5.5 mm.; middle of abdomen, 6.5 mm.; length of second joint of first pair of legs, 4.5 mm.; its width, 0.6 mm.; length of first joint of second pair of legs, 2 mm., its width, 1.9 mm.; length of second joint of same, 5.5 mm., its width, 0.85 mm.; length of first joint of third pair of legs, 2.5 mm., its width, 2.25 mm.; length of second joint of same, 6.75 mm., its width, 1.25 mm.; greatest length of any leg (as far as preserved), 10.5 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1745.

Family Architarboidae Scudder.

Cephalothorax variable in form but at least half as large as the abdomen. Coxae radiating from a central pit, a median line, or from a broad triangular space, its base on the abdominal margin. Abdomen orbicular or oval, broad at base with a more or less distinct lateral ridge on each side, converging toward the anus; segments from seven to nine in number, visible below, though the basal ones often extremely shortened in the middle; no abdominal appendages.

This appears to be the best developed among the families of paleozoic Anthracomarti, especially in America where four genera occur, most of them, so far as known, peculiar to the New World.

Geraphrynus Scudder (γῆρας, Phrynus, nom. gen.).

Geraphrynus Scudd., Proc. Amer. Acad. Arts Sc. xx, 16 (1884).

Allied closely to Architarbus; the body is compact with no constriction at the sides between the cephalothorax and abdomen, agreeing in its general structure with Architarbus, but differing from it considerably in detail. The contour of the body is ovate, but instead of being rounded in front as in Architarbus, it is pointed and angulate, while behind it is also pointed, though roundly. The cephalothorax occupies a little less than half of the body, and the pedigerous coxal segments which, as in Architarbus, are truncated wedge-shaped, enlarging distally, meet in a common median longitudinal ridge, the sides of which are rather strongly tectiform; this ridge runs from the extreme front to the posterior edge of the hindmost pedigerous segment, or through about two-thirds the length of the cephalothorax; behind it is the posterior shield of the cephalothorax, the anterior triangular fragment of which slopes upward to the ridge, while the hinder portions with their transverse scorings and ridgings lie on a plane below. Both anterior and posterior parts of this shield extend laterally nearly to the borders of the body, and are thus much broader and comparatively shorter than in our species of Architarbus.

The postthoracic plate is small and resembles that of Architarbus but is more triangular. The abdomen resembles that of *Architarbus rotundatum*, since this postthoracic plate, as

there, crowds down the middle of the six following segments, all of which reach the margin and are wider there than in the middle;[1] while the last three joints are, again as there, extremely broad and uniform; similar lateral furrows are also found in each.

This genus is American and a single species is known.

Geraphrynus carbonarius.

Pl. 40, figs. 1, 9, 10, 12.

Geraphrynus carbonarius Scudd., Proc. Amer. Acad. Arts Sc. xx, 16-17 (1884).

The median ridge of the cephalothorax (fig. 10) is flat upon the summit, with its lateral edges a little raised, so as to cause the rest to form a flat groove; the pedigerous coxal segments are very faintly punctulate, so as to be scarcely perceptible; the first pair taper more rapidly toward the interior than the others from the shape of this part of the body and terminate in a point, while the others present to the median ridge an edge; the others taper about equally, their interior margins being a little more than half as long as their exterior. The posterior shield has its front edges divaricating at considerably more than a right angle; at the base of the anterior sloping triangle is a transverse rounded ridge of considerable width, its posterior margin limited by a very broad and shallow double crescentic line; following this, opposite the anterior margins of the first abdominal segment is a similarly waved grooved ridge, the grooves of either side fading out before reaching the middle line; the sinuous posterior margin of the cephalothorax follows hard upon this. This posterior shield of the cephalothorax is faintly punctulate but more distinctly than the pedigerous segments (coxae).

The postthoracic shield is similarly punctulate, while the abdomen is profusely and rather distinctly punctate (fig. 9); the postthoracic shield is triangular, more than half as long as broad, extending laterally over about one-half of the body. The first six abdominal segments are uniform in size at the margin of the body where they occupy nearly one-half of the abdomen, but mesially are crowded down less and less strongly in passing backward, the last showing it more in being narrowed centrally than in any other way. The last three segments are equal in length though constantly decreasing in width, and the extremity of the body is marked by a circular impression. The lateral furrows of the abdomen extend from the third segment backward, being sharp on the narrower, deeply impressed but carrying the surface with it on the broader, segments, so as to leave the outer narrower portion arched. There is besides a faint ridge down the middle of either lateral half of the abdomen across all the segments, but fading out toward the hinder extremity.

Besides the body, however, there are several fragments of legs and palpi, the surface of all of which is heavily punctate. The palpi are the most perfect, nearly or quite the whole of one and half of the other being present; they are attached at the extreme front of the head and extend backward and outward on either side; they consist of seven joints, the first two small, quadrate, subequal, together reaching to the division line between the first and second pair of pedigerous segments, each a little longer than broad. The

[1] Nothing of this sort occurs in the English *Architarbus subovale* Woodw., and it would appear probable that a different surface of the body was exposed; and as it seems tolerably clear that the dorsal surface of Geraphrynus is exposed, Woodward's specimen probably shows a ventral aspect.

next three segments are larger and longer, subequal, but each a little longer than the preceding, submoniliform, being largest apically, the angles rather square; the sixth joint is as long as the fifth but slenderer and equal, while the seventh is a mere rapidly tapering bluntly pointed cap to the sixth. The surface of all but the last three joints is flat or equally rounded, while these terminal joints have a common median ridge of considerable strength. As preserved, there is next the anterior margin a very deep rounded groove occupying nearly half the width of the joint; the opposite margin has also a pronounced but narrow groove and between them is a high rounded ridge, narrower than the first mentioned groove, terminating in the middle of the last joint where the lateral grooves join; they are slender. From the single fragment of one of the anterior pairs of legs that remains, apparently of the fifth joint, these were scarcely stouter; but the hinder pairs are twice as stout, and very heavily punctate; of the third pair the first four joints are preserved in whole or in part upon either side. The first joint is too obscure for description; it can only be said to have been small, and probably of the same size and perhaps of the same form as the second which is quadrate (it is only seen perfectly upon one side), about twice as long as broad; the third joint is of similar form but longer and perhaps slightly broader at its distal than its basal extremity; it is half as long again as the preceding joint, and is followed by a fourth joint exactly like itself; all the joints of this leg, with the possible exception of the basal, are heavily ridged as in the front legs but not so conspicuously. Of the fourth pair of legs only what are perhaps the third and fourth joints remain (and not completely); if they are these joints they agree altogether with those of the third pair of legs. The distinction in size between the base and apex of the joints of all the legs has been exaggerated by the artist.

Length of the body, 19 mm.; breadth of same, 9.5 mm.; length of median furrow, 6 mm.; last three abdominal segments, 6 mm.; palpi, 11 mm.; breadth of same, 5 mm.; length of third joints of third pair of legs, 2.5 mm.; breadth of same, 1 mm.

This description was originally drawn up from a single specimen from Mazon Creek, submitted to me by Mr. R. D. Lacoe under the number 1701ab. Since it was written, the same gentleman has sent me four more specimens from the same locality all of which are believed to belong here, although they range in size from 16.5 mm. to 21 mm. in length and from 8 mm. to 11 mm. in breadth. In one of them, No. 1701cd (fig. 1), the legs are unusually well preserved, one in particular, apparently the third pair, being nearly complete, showing nearly the whole of five joints, the terminal being simply pointed, and their size, counting from the tip, being as follows: first or terminal joint, length, 1.85 mm., breadth at base, 1 mm.; second, length, 2.2 mm., breadth at base, 1.5 mm.; third, length, 2.2 mm., breadth at base, 2 mm.; fourth, length, 2.1 mm., breadth at base, 2.1 mm.; fifth, length, 2 mm. The fourth pair of legs is slightly longer.

Geratarbus gen. nov. (γῆρας, τάρβος)

Cephalothorax suborbicular, the front rounded or very broadly angulate, about half as large as the abdomen, or a little more than that, but either distinctly narrower than the abdomen or separated from it by a marked lateral constriction. Coxae radiating from a short median line, which apparently lies at the bottom of a shallow central pit. Legs

stout and tolerably long. Abdomen oval, considerably constricted at the base, composed of nine segments, of which five of the basal ones are very narrow, at least on the under surface, but transverse and not angulate, the remainder longer and subequal or lengthening posteriorly.

This genus is so far known only from America by two very distinct species, both described below. It is possibly nearly related to Eotarbus Kušta from the Bohemian coal.

Geratarbus lacoei sp. nov.

Pl. 40, fig. 11.

The cephalothorax is nearly orbicular and the wedge-shaped pedigerous segments subequal; the posterior border shows a weak, broad, and rounded emargination. Only the very base of the first pair of legs can be seen; of the others on one side or the other three or four joints each; in the two middle pairs the first three joints are subequal, about half as long again as broad, flattened and a little arcuate, the anterior edge produced at tip and base, so as to form by the union of the adjacent joints a decided dentiform spine directed forward and outward, and more distinct on the second than on the third pair of legs, both of which curve forward; the last pair of legs is directed backward and is differently constructed, having no such compound tooth, though both outer and inner apices are slightly produced and rounded; the first joint is scarcely longer than broad, the second and third subequal and nearly twice as long as broad, all of similar breadth to those of the other legs.

The abdomen broadens rapidly from its base over the two basal segments until it is nearly a third broader than the thorax, then tapers, at first gently, afterwards rapidly, with a well rounded extremity, the whole only a little longer than the greatest breadth; all the joints are transverse, the first five very short, the sixth twice as long, the eighth three times as long, the seventh midway in length between these, and the last nearly equal in length to the preceding two. The lateral sulcus is distinct but not deep, separating a very narrow side piece from the main body of the abdomen.

The whole body is rather finely and uniformly punctate, the legs much more coarsely and distinctly.

Length of body, 11 mm.; cephalothorax, 4.8 mm.; abdomen, 6.2 mm.; breadth of thorax 4 mm.; abdomen, 6 mm.; length of second joint of second pair of legs, 1.3 mm.; of third pair, 1.5 mm.; of fourth pair, 1.8 mm.; breadth of last, 1.2 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1765ab.

Geratarbus scabrum sp. nov.

Pl. 39, fig. 5.

Cephalothorax apparently orbicular but for its truncate hinder extremity, but in the specimen turned a little so that the median line is thrown (as seen in the figure) to the left. The upper surface appears to be exposed so that the form of the subordinate parts can scarcely be seen. Fragments of the legs are preserved, showing parts of every pair but the first; all are flattened; the basal joints of the second and third pairs are more

than half as long again as broad and the three succeeding joints of the same are about two and a half times as long as broad, each more than half as long as the cephalothorax; the second joint a little the broadest, the others tapering slightly; the joints of the fourth pair are not very different.

The abdomen is shaped very much as in the last species but more smoothly rounded, much more elongated, being nearly twice as long as, and at its greatest only slightly broader than, the cephalothorax; the lateral sulcus, only distinguishable in places, is similarly close to the margin.

The whole body is coarsely, deeply and uniformly punctate, and the surface between the punctures apparently minutely and faintly punctulate, giving a scabrous appearance to the whole; the same is true of the legs though the puncta would appear to be a little shallower.

Length of body, 15 mm.; cephalothorax, 5.25 mm.; abdomen, 9.75 mm.; breadth of cephalothorax, 5.25 mm.; abdomen, 6.25 mm.; length of second joint of third pair of legs, 3 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1766ab.

Architarbus Scudder.

Architarbus Scudd., Geol. Surv. Ill., III, 568 (1868).

Cephalothorax orbicular, broadly rounded in front, much smaller than the abdomen, but not separated from it by a marked lateral constriction. Coxae radiating from a central pit. Abdomen oval, composed of nine segments, of which those on the basal half are very much shorter than the others, and on the dorsal surface are forced still more closely together by the large postthoracic plate.

Species of this genus are found in the coal measures of Silesia, Great Britain, and Illinois. In addition to the one long known from the last locality, another is described below.

Architarbus rotundatum.

Architarbus rotundatus Scudd., Geol. Surv., Ill., III, 568, fig. 4 (1868).

I have nothing to add concerning this species. It comes from Mazon Creek, Ill.

Architarbus elongatum sp. nov.

Pl. 40, fig. 4.

This species is remarkable for the great elongation of the abdomen which hardly tapers apically; it is twice as long as the cephalothorax and of equal breadth on the basal half, the last segment nearly as long as broad. On one face of the opened stone there appear to be only five abdominal segments, but on the opposite face, while the three apical segments remain the same, the basal portion is broken by very pronounced ridges and furrows into five short segments, together not half the length of the remainder of the abdomen. Only the merest fragments of the base of the legs are preserved. The

cephalothorax shows a shallow, profuse, moderately coarse punctuation; the abdomen a transverse, fine, but irregular corrugation in which the furrows seem occasionally to be deepened by punctures.

Length, 14.75 mm. (cephalothorax, 5 mm.; abdomen, 9.75 mm.); breadth, 5.25 mm.

Braidwood, Ill., from the same horizon as the Mazon Creek beds at Morris. Mr. R. D. Lacoe, No. 1702ab.

KUSTARACHNE (Kušta, nom. propr., ἀράχνη) gen. nov.

Proposed for a genus of carboniferous arachnids presumed to belong to the Anthracomarti and the family Architarboidae. The cephalothorax is orbicular, more or less embracing at its base the regularly ovate abdomen, but not so as to prevent a decided constriction between the two laterally. In the single specimen yet known, the elements are too uncertain to distinguish it in this part from the other genera. The legs which seem to have a stout basis are long and exceedingly slender. The palpi have the same slenderness but only the base is preserved. The abdomen proper is considerably larger than the cephalothorax, divided into seven segments, of which the first four are equal and longer than the last three, which are followed by a protuberant pygidium composed of two subsegments. It is possible that this was followed by a jointed seta; if so it could hardly fall in this place, but among the Pedipalpi where it would differ strikingly from the known forms. The irregular divisions of the abdomen do not disturb the regular curve of the sides.

Named in honor of Professor Johann Kušta of Rakonitz who has so greatly enlarged our knowledge of carboniferous Arachnida by his study of the coal-fauna of Bohemia.

Kustarachne tenuipes sp. nov.

Pl. 40, fig. 7.

The exact limits of the cephalothorax in the only specimen are rather obscure but so far as can be seen this region is orbicular with a slightly greater breadth posteriorly. The radiation of the coxae from the central pit is a little obscure, but unquestionable, and the pit opens posteriorly with flaring sides. The legs are excessively slender, long, straight, and almost thread-like, and the palpi have at base the same form, two short and slender joints of one being visible. The abdomen is very regularly oval, the broader basal extremity being sessile but having its basal suture well defined and the lateral excision at their boundaries distinct; the last three segments of the abdomen proper, which are equal, are about half as long as the four equal, basal segments; the terminal subsegments interfere with the regularity of the form of the abdomen, extending beyond the oval; the first is of the same length as the terminal segment, but only half its breadth and semilunar in form; at either side of its base a possible globular appendage appears to be present; the last segment is as long as the penultimate but much slenderer, being fully half as long again as broad; and there are some indications on the stone (which may be fortuitous) that it was followed by a slender seta; the surface of the abdomen is faintly and shallowly punctate. A straight belt of lighter color than the sides and as wide as the

terminal subsegment runs down the middle of the abdomen, but there is no sign of any lateral sulcation as in neighboring genera. I have left in the figure the knob-like appendages mentioned above at the outer base of the apical subsegments of the abdomen, drawn by the artist, but I believe them to be purely accidental and perhaps wholly foreign to the creature as they are really distinctly present only on one side as a mere depression.

Length of body, 11.5 mm.; width of cephalothorax, 4.5 mm.; length of abdomen, not including terminal segments, 7 mm.; its width, 4.75 mm.; width of terminal subsegment, 1.25 mm.; length of legs (imperfect) beyond body, 13 mm.; their width, 0.3–0.5 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, No. 1756 ab.

Anthracomartus Karsch.

Anthracomartus Karsch, Zeitschr. deutsch. geol. Gesellsch., 1882, 560 (1882).

Cephalothorax quadrate, the front square, or scarcely convex, about half the size of the abdomen; the coxae laterally affixed, radiating from a broad triangular sternal plate, the base of which forms the posterior margin. Sides of the body showing a distinct though slight constriction between the cephalothorax and the abdomen by the more convex sides of the latter. Abdomen orbicular, a little longer than broad, composed of seven segments of similar length.

This is apparently the most abundant type of Arachnida in the carboniferous formation. Kušta has found four or five species in Bohemia alone, one is found in Silesia, another in Belgium, and at least two in our own coal. These last are described below.

Anthracomartus trilobitus.

Pl. 39, figs.7–10.

Anthracomartus trilobitus Scudd., Proc. Amer. Acad. Arts Sc., xx, 17 (1884); Comptes rend. soc. ent. Belg., (3) No. 62, p. 85, fig. (1885).

Although more than half a dozen specimens of this species have been obtained, the abdomen is the only part that has been secured in a complete condition, the cephalothorax being incomplete if present, and the appendages in no case present. It offers, however, striking differences from the other species known. The cephalothorax was hexagonal in outline, the front and hind margins forming the longest and subequal sides, and the lateral margins being roundly angulated behind the middle, the hinder lateral margins formed the shortest sides of the hexagon; the front is nearly straight, slightly convex, and a little longer than the straight or even slightly concave hind margin; the surface is nearly flat but slightly domed, with the transversely ridged hinder margin separated from the main mass by a straight transverse furrow. The abdomen is very broad and well rounded, excepting in front where the extremely broad base is almost straight, gently convex, and on each side extends far beyond the cephalothorax, being even here, where the abdomen is narrowest, wider than the widest part of the cephalothorax; and as the hinder portion of the cephalothorax rapidly narrows backward, an unusually deep excision separates it from the abdomen. The outer angles of the base of

the abdomen are distinct and not rounded, and the first course of the lateral slope as the abdomen enlarges is in exact continuation of the direction of the anterior half of the sides of the cephalothorax; the abdomen widens to beyond its middle, so as to be half as broad again as the cephalothorax, and then narrows, the outline of its apical half being an almost exact semicircle with the central point of the abdomen (near the middle of the fifth segment) for its centre. A scalariform incised line runs on either side obliquely inward from opposite the outer limits of the cephalothorax to either side of and in close proximity to the large circular or more often transversely oval anus, dividing the body into three subequal longitudinal thirds and giving it a trilobitic aspect, which is more pronounced from the fact that the central region is nearly flat or only slightly domed, while the sides fall off as far as the again flat, lateral flanges; these are separated about as distinctly from the rest of the body by an incised line subparallel to the margin and dividing the lateral lobes as a whole into nearly equal halves, extending also across the middle of the seventh segment and dividing it just beyond the anus into an anterior and posterior half.

The entire surface of both cephalothorax and abdomen is delicately, uniformly, and rather sparsely granulate. In the original description it was described as punctate, but this is apparently a mistake, the surface being punctate only in casts, though it is difficult in the flattened condition of all the specimens to speak confidently.

Length of cephalothorax, 5.25 mm.; its greatest width, 6.75–7.5 mm.; width at posterior extremity, 4.5–5.5 mm.; length of abdomen, 8–12.5; width at base, 5.75–8.25 mm.; at widest point, 8–12.5 mm.

The specimens were found on a dark gray carbonaceous shale associated with ferns, in the subconglomerate coal measures six miles northeast of Fayetteville, Ark., by Prof. F. L. Harvey of Fayetteville. Some of the specimens are in Mr. R. D. Lacoe's collection under the number 1753.

Anthracomartus pustulatus.

Pl. 40, figs. 5, 8.

Anthracomartus pustulatus Scudd., Proc. Amer. Acad. Arts Sc., xx, 18 (1884).

The stone on which the single known specimen occurs is broken just at the front edge of the cephalothorax, as is shown by the course of the front pairs of legs and of the palpi in the face of the broken wall (fig. 5). If this break has not interfered, as looks possible, with a projecting front, the cephalothorax was squarely truncated in front and was of a quadrate form, narrower, however, in front than behind and with tolerably straight sides, the hind margin straight or a little concave. The surface of the cephalothorax is however the most remarkable thing about it, the sides being strongly elevated, and the middle third deeply sunken in a longitudinal furrow rapidly widening posteriorly, from the bottom of which a sharp median ridge arises with abrupt sides, gradually increasing in elevation and thickness from the middle of the front half where it arises, to the middle of the hinder half where it abruptly terminates, but nowhere rising to half the height of the sides. The abdomen on the contrary is strongly arched, the central field somewhat flattened and separated from the lateral by distinct carinae. The outline of the abdomen,

though nowhere seen on the stone, appears to be regularly obovate, broadest at or before the middle and much broader than the cephalothorax, with which it appears to be united throughout the base, the sides of the body showing little excision at their junction. The abdominal segments are equal in length. The entire surface of both cephalothorax and abdomen is closely covered with very irregularly polygonal, or rounded subovate, sunken cells of varying size, but generally tolerably large, the largest forming pyriform cells lining internally the abdominal carinae, one to each segment, the broadest end anterior. The legs are moderately stout, very long, thickened at the joints, the fourth pair apparently the longest, the first pair comparatively small; the palpi, as far as they can be seen, apparently similar to the front legs but still smaller.

Length of body, 15 mm.; cephalothorax, 6 mm.; abdomen, 9 mm.; width of cephalothorax in front, 4 mm., behind, 7 mm.; abdomen, 8 mm.; length of first two joints of first pair of legs, 4.5 mm.; of third pair, 5 mm.; of fourth pair, 5 mm.; first four joints of third pair of legs, 12 mm.; of fourth pair, 13.5 mm.; length of second joint of first pair of legs, 3 mm.; of same (?) joint of palpi, 1.75 mm.

Mazon Creek, Ill. Collection of Mr. R. D. Lacoe, No. 1752.

Order PEDIPALPI Latreille.

Family Geralinuridae Scudder.

Cephalothorax divided into two masses: the hinder much the smaller, short and transverse, and carrying only the hindmost legs; the front portion large, tapering anteriorly, and furnished with long and slender cheliceres. Abdomen subfusiform. While most nearly related to the Thelyphonidae, this family, by the division of the cephalothorax, shows some affinity to the Nyctalopidae. Two genera have been found belonging here.

Graeophonus gen. nov. (γραῖος, φόνος).

Cephalothorax remarkably short and stout, rounded quadrate (especially rounded in front, nearly quadratiform behind, the sides nearly straight, the hinder margin gently convex), divided into radiating pedigerous segments. Palpi very stout, chelate at tip. First pair of legs like the others in all general respects, very stout, flattened and tapering, of no great length. Abdomen ovate, largest in the middle, rather narrowly attached at base, composed of twelve similar segments, excepting that the last three rapidly narrow and are considerably shorter than the others, but the posterior curve of the abdomen is not interrupted to form a post-abdomen as in other Pedipalpi. Whether an articulated seta follows the last joint cannot be told from the specimen preserved; a pair of distant, distinct, and divergent furrows are seen on the first and second abdominal segments of a cast of one specimen, reaching halfway across the second segment, and occupying the place which the "combs" of modern scorpions occupy.

This genus pretty plainly falls into the Pedipalpi on account of the stout chelate palpi and the number of abdominal joints; but the absence of a post-abdomen, perhaps also of a seta, the undifferentiated character of the first pair of legs and the radiated arrange-

ments of the pedigerous segments of the cephalothorax separate it widely from all known Pedipalpi ancient or modern. In the characteristics of the body proper it approaches decidedly the contemporaneous Anthracomarti.

Graeophonus carbonarius.

Pl. 40, figs. 2, 3, 6.

Libellula carbonaria Scudd., Can. nat., (2), VIII, 88–89, fig. 1 (1876).

Cephalothorax (fig. 3) quadratiform posteriorly, the hinder angles scarcely rounded, the hinder margin gently convex, and the sides straight; anteriorly the front is regularly and rather strongly convex, the whole cephalothorax being nearly half as broad again as long; on the posterior half is a sharp and deep median sulcation which increases in depth posteriorly and at the posterior limit ends in a circular pit which appears to involve also a part of the first abdominal segment. The whole surface is minutely and delicately punctate, as is also that of the legs and palpi. What are apparently the third joints of the legs are disproportionately long and tapering. The abdomen is regularly obovate, nearly twice as long as broad, the first to the fifth joints longer and equal, the sixth to the ninth slightly shorter and subequal, the tenth to the twelfth scarcely more than half as long as those directly preceding. The surface of the abdomen is punctate as the rest of the body.

Length of whole body, 15.5 mm.; cephalothorax, 5 mm.; abdomen, 10.5 mm.; breadth of cephalothorax, 7 mm.; abdomen, 7 mm.; length of palpi, 6 mm.; breadth of palpi, 1.6 mm.; longest fragment of legs (second pair), 12 mm.; apparent length of third joint of this pair of legs, 7.5 mm.; its breadth at base, 1.75 mm.; at tip, 1 mm.

Mazon Creek, Ill. Collection of Mr. R. D. Lacoe, No. 1762.

The above description was drawn up from the specimen above mentioned before it was recognized as the same species as that described by me many years ago from an abdomen alone, under the name of *Libellula carbonaria*, presuming it to be a larva. A direct comparison of the two, for the opportunity for which I am indebted to the kindness of Sir Wm. Dawson, leaves little doubt on this point. No marks of divergent furrows or ridges can be seen on the basal segments, however (figs. 2, 6), and it further differs from the above in that the posterior border of the eighth segment is broadly, roundly, and rather deeply excised. In addition one may see large, faint, shallow depressions on either side of each of the larger segments, at equal distances from either border and the lateral ridge, which look as if in the position of stigmata. Finally there is a mesial, apical, small, triangular depression on the last segment as if the cast of a basal fragment of a seta, and which formerly led me to think the segment bilobed.

The specimen is 14 mm. long and 8.25 mm. broad, though apparently it is crushed out of shape a little, and should be considered 7.2 mm. broad.

The specimen comes from Cape Breton and is now in the museum of McGill College, Montreal.

Geralinura Scudder.

Geralinura Scudd., Proc. Amer. Acad. Arts Sc., XX, 19 (1884).

Cephalothorax ovate, the front rounded, narrower than the squarely truncate posterior

margin, the sides well rounded, the whole not more than half as large as the abdomen, which is cylindrical, perhaps depressed, and composed of nine principal joints, of which the first three are a little shorter than the others, followed by a post-abdomen of three much contracted joints, and this by the jointed thread peculiar to the family, and which is as long as the abdomen. A pair of eyes on the front of the cephalothorax. Palpi large, robust, composed of three similar joints, spinous within, and the apical coarsely chelate. First pair of legs thread-like, no stouter than the tail, and longer than it; second and third pairs of legs moderately slender, equal, the last pair similar but considerably longer, supported by a transverse independent joint between the cephalothorax and abdomen.

This genus, first described in June, 1884, was brought to the attention of the American Academy only nine days before another species of the same genus was described by Kuśta to the Bohemian Academy; a fact the more striking since up to that time no Pedipalpi had ever been found fossil even in tertiary or secondary rocks, unless credit be given to Serres' mention of a species in the tertiary marnes of Aix. Kuśta has since described several species from the Bohemian coal.

Geralinura carbonaria.

Pl. 39, figs. 1, 3, 4.

Geralinura carbonaria Scudd., Proc. Amer. Acad. Arts Sc., xx, 19–20 (1884).

Cephalothorax broadest in the middle, but tapering more rapidly in front than posteriorly, the front triangularly produced but the extreme tip rounded; apparently a pair of globular eyes are situated in front as in *G. bohemica*, but larger, notwithstanding that they are seated on a much narrower spot. The front pair of legs are of the same size as the tail; the second pair have the femur hardly half so stout as that of the hind pair, which is nearly as broad as one of the middle abdominal joints, that of the middle pair approaching the former rather than the latter. The abdomen is regularly obovate, twice as long as the thorax even excluding the post-abdomen, and half as broad again as that. The post-abdomen composed first of two joints, together half as long as broad and one-third as broad as the abdomen, next of a single quadrate joint, followed by the thread which is about one-fourth or one-fifth as broad as the tip of the post-abdomen, and about as long as the body, composed of numerous joints, as far as can be seen about twice as long as broad. In one of the two specimens found, the body is piceous from carbonaceous matter, but interrupted at the abdominal interstices and traversed irregularly by broken, longitudinal, slenderer interruptions of the color of the stone.

Length of body to base of tail (*a*), 16 mm.; (*b*), 13 mm.; of tail (*a*, broken), 4 mm., (*b*, probably perfect), 12 mm.; of cephalothorax (*a*), 4 mm.; postthoracic plate (*a*), 0.75 mm.; abdomen (*a*), 8.5 mm.; postabdomen (*a*), 2.5 mm.; breadth of cephalothorax (*a*), 2.6 mm.; postthoracic plate (*a*), 1.75 mm.; abdomen (*a*), 4.5 mm.; postabdomen (*a*), 1.4 mm.; thread (*a*), 0.25 mm.; breadth of first pair of legs (*a*), 0.25 mm.; second pair (*a*), 0.5 mm.; third pair (*a*), 0.75 mm.; fourth pair (*a*), 1 mm.; length of femora of third pair (*a*), 3.5 mm.; of fourth pair (*a*), 5 mm.

Mazon Creek, Ill. Mr. R. D. Lacoe, two specimens, Nos. 1751a–d.

The species differs considerably from *G. bohemica* Kuśta sp., first in its much smaller size, then in its much more pointed and ovate cephalothorax. It would appear indeed

as if Kušta had more than one species before him, as his figures I and IV differ remarkably, fig. I having a cephalothorax scarcely half so long in proportion to its breadth as fig. IV, and its abdomen is strongly constricted at the base, while in fig. IV the latter only tapers gently in front. Our own species has the abdomen much broader and larger than the cephalothorax, and tapers in front considerably but not so rapidly as in Kušta's fig. IV. More recently Kušta has described other species, but they seem no nearer ours.

EXPLANATION OF PLATES.

PLATE 39.

Figs. 1 and 3 are by J. Henry Blake; figs. 2, 5–8, 10 by Mrs. Katherine Peirson Ramsay; figs. 4 and 9 by J. H. Emerton.

Fig. 1. *Geralinura carbonaria* $\frac{3}{4}$.
Fig. 2. *Poliochera punctulata* $\frac{2}{1}$.
Fig. 3. *Geralinura carbonaria* $\frac{3}{4}$.
Fig. 4. *The same* $\frac{2}{1}$.
Fig. 5. *Geratarbus scabrum* $\frac{4}{1}$.
Fig. 6. *Poliochera punctulata* $\frac{10}{1}$; a fragment from the middle of the abdomen to show surface structure.
Fig. 7. *Anthracomartus trilobitus* $\frac{4}{1}$.
Fig. 8. *The same* $\frac{4}{1}$.
Fig. 9. *The same* $\frac{3}{1}$.
Fig. 10. *The same* $\frac{4}{1}$.

PLATE 40.

Figs. 1, 3, 4, 7, 12 are by J. H. Emerton; figs. 2 and 6 by S. H. Scudder; figs. 5, 8, 11, by Mrs. Katherine Peirson Ramsay; and figs. 9 and 10 by J. S. Kingsley.

Fig. 1. *Geraphrynus carbonarius* $\frac{3}{1}$.
Fig. 2. *Graeophonus carbonarius* $\frac{4}{1}$.
Fig. 3. *The same* $\frac{2}{1}$.
Fig. 4. *Architarbus elongatum* $\frac{2}{1}$.
Fig. 5. *Anthracomartus pustulatus* $\frac{8}{1}$; front view.
Fig. 6. *Graeophonus carbonarius* $\frac{3}{1}$.
Fig. 7. *Kustarachne tenuipes* $\frac{2}{1}$.
Fig. 8. *Anthracomartus pustulatus* $\frac{4}{1}$.
Fig. 9. *Geraphrynus carbonarius* $\frac{6}{1}$; a portion of the first broad abdominal segment, to show the surface structure.
Fig. 10. *The same* $\frac{2}{1}$.
Fig. 11. *Geratarbus lacoei* $\frac{4}{1}$.
Fig. 12. *Geraphrynus carbonarius* $\frac{2}{1}$.

XII. The Insects of the Triassic Beds at Fairplay, Colorado.

By Samuel H. Scudder.

Read May 7, 1890.

EARLY in 1882, Mr. Arthur Lakes, professor in the Colorado School of Mines, discovered a bed of plants and insects near Fairplay, Colorado, in rocks much older than any that had before yielded insect remains west of the Great Plains; the two or three specimens he sent me were sufficient to prompt a more thorough exploration of the locality, which I was able to make the following summer, resulting in the discovery of a fauna and a flora of considerable interest.

The plants have been studied by Mr. Lesquereux,[1] who pronounces the species, some thirty in number, but in a very fragmentary condition, to belong to permian types, and declares the evidence to be decisive on this point.

The animal remains consist almost exclusively of insects, and are two-thirds as abundant in species as the plants, an exceptionally large ratio in beds where both occur. These insects form an assemblage wholly different from anything before known, and, in contradiction to what Mr. Lesquereux says of the plants, clearly belong to types of a more modern character than any the paleozoic series has yet disclosed. It is not often that one may speak so positively in the discussion of fossil insects, especially when not a single one of the species and only the smaller portion of the genera found have been previously known. But in this case all but two or three of the specimens obtained (some eighty in number) belong to a group which of all paleozoic insects has received the most attention, namely, the cockroaches. This great preponderance of cockroaches, and the fact that the known genera found in this collection have hitherto been discovered only in carboniferous and permian rocks, would lead us at first to refer the beds in which they occur to one of the paleozoic series; but the presence of the other forms, and even the characteristics of those which are referable to carboniferous and permian genera, unmistakably point to a later horizon.

As has been repeatedly pointed out by me, paleozoic cockroaches are distinguished

[1] On some specimens of permian fossil plants from Colorado. Bull. Mus. Comp. Zool., vii, 243.

from living types by the complete interdependence of two of the veins of the fore wing, and by the fact that the anal veins of the same wing impinge successively upon the inner margin and do not either fall upon the anal furrow or become clustered together at the outer point of the anal area; and I have accordingly grouped them under the name Palaeoblattariae to distinguish them from their descendants the Blattariae proper. Now as not only all the living cockroaches belong to the Blattariae proper, but the same is true of all mesozoic cockroaches later than the trias,[1] it becomes a matter of special interest to inquire into the position of these Fairplay cockroaches, which number eighteen species.

Eleven of the species and five of the seven genera belong to the Palaeoblattariae. These five genera are Etoblattina (2 sp.), Spiloblattina (4 sp.), Anthracoblattina (1 sp.), Petrablattina (2 sp.), and Poroblattina (2 sp.). Only five of the species belong to genera previously known, Spiloblattina and Poroblattina having been established upon and still being known only by the Fairplay fossils. But the difference is more marked than this; for at least one of the species referred to Etoblattina is an aberrant form with an excessively long internomedian vein; and both the species of Petrablattina agree in differing from those heretofore known to a very considerable degree. Of the new genera, Spiloblattina is very peculiar in the strongly divergent and then convergent curve of the externomedian and internomedian veins around a large stigma near the middle of the wing, unknown in any other cockroach, ancient or modern, so far as I know; but otherwise it is related to Etoblattina; while Poroblattina is more nearly related to Petrablattina, and especially to the two new species of that genus from this locality.

The average size of these Fairplay Palaeoblattariae is much less than that of the paleozoic Palaeoblattariae in general. The average length of the front wings of the paleozoic species is 26 mm.; that of these Fairplay Palaeoblattariae, 16 mm. This fact has its value, for the jurassic species are nearly all of very small size, and the wing-length of the remaining species from Fairplay (*i. e.*, those which do not belong to the Palaeoblattariae) is less than 8.5 mm., ranging from 6.5–11.5 mm. This agrees completely with the size of mesozoic species already known. The average of all the Fairplay cockroaches is less than 13.5 mm.

As to the seven cockroaches from Fairplay which belong to the Blattariae, the characteristics of their venation as well as their small size show them to be closely allied to jurassic forms, although the two genera to which they belong are peculiar so far as yet known to Fairplay. One of them is distinctly allied to Rithma, as defined by me in my memoir on mesozoic cockroaches (*loc. cit.*), while all the species have a decided mesozoic aspect and would at once be considered liassic or at least jurassic by any one at all familiar with the forms already known from these deposits. They have on the other hand an entirely different aspect from any and all paleozoic forms, and present no points of close comparison with any Palaeoblattariae excepting some of those mentioned above from the same Fairplay beds, notably with the genus mentioned under the name of Poroblattina, which one of the genera not a little resembles. The manner in which the change of the venation was brought about has been stated by me in my memoir on mesozoic cockroaches.

[1] See Mem. Bost. Soc. Nat. Hist., III, 439 *seq.*

The few insects other than cockroaches emphasize the mesozoic aspect of the rest of the fauna.

We have then at Fairplay an assemblage of forms altogether different from anything hitherto found in the paleozoic series on the one hand, or in the jurassic beds on the other. They show a commingling of strictly jurassic forms with a larger proportion of types which may be called upper carboniferous or permian with a distinct jurassic leaning. There is therefore a strong probability that the beds in which they occur belong to the intermediate formation, the triassic.

If this should be proved, Mr. Lake's discovery will have an added interest, from the fact that almost nothing is known either of the plants or of the insects of this formation. Of the plants, it is only necessary to point out that in the paucity of data, the upper paleozoic aspect of the few vegetable remains from Fairplay can have but a negative value beside the positive proof of the alliance of the insects to mesozoic forms. Of triassic insects our knowledge is exceedingly meagre; a single neuropterous larva from the Connecticut valley is all that the formation has hitherto yielded in this country. In Europe we know of only four species, each, I believe, from a single specimen; one of these is a cockroach, but it is entirely different from any of the Fairplay species, and indeed from any other known forms, so that we get no light from this quarter.

So far as I know this is the first attempt to determine the age of a deposit from its insect remains alone, and it is unfortunate for its acceptance by naturalists that the plants give it, to say the least, no support, but rather are deemed by one competent to judge, to be decidedly adverse to what is here claimed.

The paleontological contradiction shown in the plants and animals of the Fairplay beds is not unknown to American geology, as every one is aware, but I do not know that it has been pointed out in this country at this horizon or in this direction, the discordance appearing later in time, and the plants indicating a younger and not an earlier age than the animals. An exactly parallel case appears to be shown in eastern Russia, for in discussing the poorer strata of Kargalinsk, which he refers to the permian, Twelvetrees says, "as regards the flora [eleven species] the list has a paleozoic aspect, but a secondary one as respects the reptilians remains" [four species cited.][1]

All the specimens are in my own collection.

PALAEOBLATTARIAE Scudder.

Etoblattina Scudder.

Etoblattina persistens sp. nov.

Pl. 41, fig. 7; pl. 42, figs. 10, 19.

The fore wing is a little less than two and a half times as long as broad with a moderately convex costal margin and apparently a full and well rounded apex. The mediastinal vein extends somewhat beyond the middle of the wing and is provided with

[1]Quart. Journ. Geol. Soc. Lond., xxxviii, 495.

numerous oblique simple branches. The scapular reaches nearly to the tip of the wing, running in a nearly straight course, most distant from the costal margin in the middle of the wing; it begins to branch just beyond the basal third of the wing, and sends to the costal margin half a dozen or less oblique branches, subparallel to the mediastinal branches, but apically growing more longitudinal, any of which may, and the greater number do, fork at less than halfway to the margin. The externomedian vein occupies the centre of the wing, and with its branches feeds narrowly the apical margin, for it only forks three times, usually simply, near the centre of the wing, beginning a trifle earlier than the scapular vein, and the long branches are wholly longitudinal and closely crowded. The internomedian starts as if to terminate with a gentle arcuation before the middle of the outer half of the wing, sending off half a dozen moderately distant, usually simple but sometimes deeply forked, slightly sinuous, parallel, oblique branches; but when it reaches the middle of the wing, it throws off from its other side a couple of deeply forked or compound, nearly straight, crowded, longitudinal branches, which extend the range of the internomedian area almost to the very tip of the wing. The anal furrow is moderately impressed, strongly arcuate or almost bent, and the anal veins simple, moderately frequent, also strongly arcuate, and parallel.

To this species I refer with little doubt (if it belongs to any of the species here described) a prothoracic shield, independently preserved in the same shales. It is pretty strongly domed, rounded subtriangular, more than a third as broad again as long, strongly rounded in front, centrally subtruncate behind; the surface is smooth and the margins entire, but the disk shows a little behind the middle a very faint subtriangular depression, one-fourth the size of the pronotum, the apex posterior.

Length of wing, 20 mm.; breadth, 8.4 mm.; length of pronotal shield, 7 mm.; breadth, 9.75 mm.

Four fragments of wings were found, with a single pronotum, Nos. 21 and 65, 22, 29 and 69, 66, 67 and 68. The species is clearly different from anything before described, but in the apical reach of the internomedian area and the means of securing it, it resembles the later carboniferous Etoblattinae.

Etoblattina sp.

Pl. 42, fig. 20.

A second and smaller species of Etoblattina is indicated by the poorly preserved fore wing and its reverse figured as above. Like the preceding, it is about two and a half times longer than broad, with well arched costal margin, and the general course of the veins shows that it is nearly allied to that species; the details of the neuration, however, are very obscure. The mediastinal vein reaches the end of the middle third of the wing. The scapular occupies about the same area as in the preceding species, and with very similar, crowded, pretty longitudinal veins. The externomedian is more obscure. The internomedian certainly differs in that the inferior branches are fewer, more longitudinal, and far longer, but there is apparently, though this is uncertain, a somewhat similar apical extension of this area, and apparently by a similar method. The anal furrow is ar-

cuate, but more broadly than in *E. persistens*, and the anal veins similarly arcuate, longer, and perhaps less numerous.

Length of wing, 12 mm.; breadth, 5 mm.

A single specimen and its reverse, Nos. 28 and 70.

Spiloblattina Scudder.

Spiloblattina Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 35–36.

This genus is allied to Etoblattina, but differs from it and from all other genera of Blattinariae in the divergence of the scapular and externomedian veins beyond the middle of the wing, and then their rapid convergence beyond a more or less conspicuous elongated spot (whence the generic name) which fills the space so produced; a similar arrangement is seen even more conspicuously between the externomedian and internomedian veins, where the spot is much larger and round.

This genus is only known from the Fairplay triassic, where four species occur. *S. gardineri* may be considered the type.

TABLE OF THE SPECIES OF SPILOBLATTINA.

Scapular vein as far as its penultimate branch almost completely parallel to the costal margin, not receding from it opposite the middle of the adjoining discal stigma.
Wings relatively slender, fully three times as long as broad.
Scapular faintly approaching the externomedian vein to enclose the stigma between them . **1. S. gardineri.**
Scapular in no way approaching the externomedian vein to enclose the stigma between them **2. S. triassica.**
Wings relatively broad, not over two and a half times longer than broad . . . . . **3. S. guttata.**
Scapular vein distinctly receding from the costal margin opposite the middle of the adjoining discal stigma **4. S. marginata.**

1. Spiloblattina gardineri.

Pl. 41, figs. 4, 6, 8, 10.

Spiloblattina gardineri Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 36.

This was the most common species found at Fairplay, and a number of tolerably perfect fore wings well exhibit the characteristic discal stigma of the wings; some hind wings also occurred, and one somewhat crushed specimen with parts of all the wings and some of the body. The fore wing is long and slender, more than three times as long as broad, the costal margin very gently convex, the tip produced and attenuated but rounded. The mediastinal vein terminates some way beyond the middle, approaching the margin very gradually and emitting numerous parallel simple veins. The scapular vein runs parallel to the costal margin, slightly more removed from it in the apical than in the proximal half, and terminates a little before the tip of the wing; it first branches a little before the middle of the wing, and has many offshoots usually forked, sometimes, especially the first one, compound. The externomedian vein usually begins to branch beyond the middle of the wing opposite the distal end of the stigma between it and the scapular vein, and its longitudinal, more or less forked branches, which are sometimes superior, sometimes apical, fill the apex of the wing; to form the enlarged cell for the larger stigma, the curve of the main externomedian vein is graceful and gradual. The internomedian vein at first descends rapidly toward the margin as if to terminate near the middle of the outer half, but shortly before reaching it, it bends outward with a sinu-

ate curve embracing the discal stigma next it and terminates about as far out as the scapular vein; its branches are almost always simple, gently arcuate, and more distant than in other parts of the wing, except those that arise nearest the somewhat sudden and considerable turn in direction, where they are generally deeply forked. The anal furrow is not pronounced, almost bent rather than arcuate, and terminates hardly beyond the basal third of the wing.

The whole wing is of a dark color, excepting for the two stigmas which are light or diaphanous and for occasional light streaks in the broader spaces, particularly in the neighborhood of the stigmas and on the costal side; besides, the whole wing, as also the hind wing, is covered with a delicate scarcely perceptible mesh of fine lines.

The outer half or less of the hind wings is preserved in several instances, showing that this wing was of about the same length as the fore wing but of a different shape, having a straighter costa, a fuller hind margin, and a more pointed apex, which was far above the middle line of the wing. The mediastinal area (fig. 4) was very narrow, and subequal, terminating somewhat abruptly when it had extended over nearly five-sixths of the wing, and had numerous very oblique branches. The scapular does not branch before the distal third of the wing, and then reaches with a few longitudinal and mostly simple veins to the tip. The externomedian area is narrowly fan-shaped, the first divarication occurring near the middle of the wing and most of the forking of the longitudinal branches near the middle of the apical half. The internomedian vein reaches a little further out than the scapular, but the main vein is nearly straight, and the branches mostly simple, and only gently arcuate and parallel, so as to be very different from the fore wing.

The pronotal shield can be seen and then but obscurely only in a single instance. It appears to be rather small and transversely obovate.

Length of fore wing, 17.5 mm.; breadth, 5.5 mm.

Eleven more or less perfect specimens were found by our party, the first and best specimen (fig. 6) by my son. I have accordingly named the species for him.

2. Spiloblattina triassica.

Pl. 41, fig. 1.

Spiloblattina triassica Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 36.

Two incomplete fore wings are preserved showing that the species is nearly allied to the last; the veins are more delicate, however, and have other differences which will be pointed out. Although only the costal margin is in any degree preserved, and this is straighter than in *S. gardineri*, the form of the wing appears to be essentially the same and with the same proportions. The mediastinal vein and its branches are precisely as in *S. gardineri*. The scapular vein is also very similar, and its branches similarly arranged and forked, but they are a little more longitudinal and arise earlier, the first some way before the middle of the wing; the main vein is also exceptionally straight, showing, as it passes the stigma between it and the externomedian vein, no disposition to curve toward the latter. The externomedian vein is practically a repetition of the same vein in *S. gardineri*. The internomedian passes at rather a less distance from the preceding

vein than in *S. gardineri*, producing a small stigma, but its further structure cannot be told from either of the specimens, and the anal area is not preserved.

In this species the wing appears to be more slender than in the others, although the exact proportions cannot be given from the imperfection of the specimens; all the branches have a more longitudinal and less arcuate course, the externomedian and scapular veins scarcely part from each other to give place to the stigma, and the divergence of the former and the internomedian veins is also less conspicuous. The wing was probably about 15 mm. long, and 5 mm. broad.

Two specimens obtained, Nos. 23, 59 and 60.

3. Spiloblattina guttata.

Pl. 41, fig. 2; pl. 42, fig. 14.

Spiloblattina guttata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 36–37.

Although no perfect fore wing has been discovered, it was evidently stouter than in the other species found and was perhaps not much more than twice as long as broad; the costal margin is nearly straight in the middle. The mediastinal area is wider than in the other species, terminating more abruptly, and is filled with less longitudinal branches pretty closely crowded; it terminates directly opposite the scapular-externomedian stigma, or a little earlier than in *S. gardineri*. The scapular vein runs in a nearly straight but slightly sinuous course at a considerable distance from the mediastinal; its branches, at first compound, afterwards deeply forked and then single, are five or six in number, scarcely more longitudinal than the mediastinal branches, and it would appear as if the last could not come very near the tip of the wing as it does in *S. gardineri;* the first vein is given off about opposite instead of far before the last branch of the mediastinal and after its second branch it begins gently to recede from the costal margin to share in the embrace of the adjoining stigma. The externomedian vein first forks about opposite the end of the mediastinal area, and sends four or more longitudinal mostly simple branches to the apical margin, the basal arcuation of the first branch serving for the embrace of the smaller, the sinuous course of the main vein for that of the larger, stigma. The internomedian vein has the same strongly sinuous course as in *S. gardineri*, and the branches are arcuate, distant, parallel, and so far as can be seen, all simple. Anal area unknown.

There is a single hind wing (fig. 14) which appears to belong here as it agrees closely with the hind wing of *S. gardineri* except that a broader wing is indicated by the greater width of both the mediastinal and scapular areas, and therefore more in accordance with the present species.

This species differs from the others in the stoutness of the wing, which is proportionally much shorter than any of the others; in keeping with this peculiarity is the greater width of both the mediastinal and scapular areas, and the more rapid descent to the margin of the termination of at least the former. In other respects the species completely resembles *S. gardineri.*

The fore wing was apparently about 15 mm. long and 7 mm. broad; the length of the fragment is 8.5 mm.

Two specimens, Nos. 19, 27.

4. Spiloblattina marginata.

Pl. 41, fig. 3.

Spiloblattina marginata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 37.

The single specimen (with its reverse) upon which this species is founded, shows the larger and more important parts of the wing, but preserves neither the inner margin nor the tip, so that its form and proportions cannot be determined; it has, however, some marked peculiarities. The mediastinal area is relatively broad with very few, distant, oblique, simple, and nearly straight branches to the main vein, and ends very gradually after the manner of *S. gardineri*, but opposite the middle of the scapular-externomedian stigma as in *S. guttata*. The relations of the scapular to the mediastinal vein are as in *S. gardineri*, but instead of a nearly straight course opposite the stigma mentioned, it actually curves so as to encroach upon the space allotted to the stigma, and the branches, forked or simple, never compound, are distant and inequidistant; apparently the vein terminates not far above the tip of the wing. The externomedian vein is very sinuous and its longitudinal branches, sometimes compound sometimes simple, are more crowded than the others, and very inequidistant, the main vein itself almost colliding with the scapular beyond the stigma. Nothing can be determined of the internomedian or anal veins. The wing differs from the others in having its darker colors concentrated in a narrow margin to all the veins, the paler colors between them forming the real ground color to the wing.

This species is remarkable for the paucity of its neuration, and for the fact that all the veins and branches are margined with a slender dark edging. The scapular vein recedes more than usually from the costal margin opposite the very slight median stigma, and the externomedian vein is consequently more than usually curved to make place for it. The probable length of the wing was 18 mm. The inner margin being lost, the width can hardly be more than conjectured, but it was perhaps 7 mm.

One specimen, Nos. 26 and 58.

Anthracoblattina Scudder.

Anthracoblattina triassica sp. nov.

Pl. 41, fig. 9.

A single specimen and very fragmentary at that, with its reverse, is pretty plainly referable to this genus, hitherto known only from the carboniferous rocks, but it differs so much from all the known species, which are not many, that notwithstanding its imperfection I have ventured to name it. It was evidently a large fore wing, and presents a fragment from the outer half of the apex; it is hardly probable that more than a quarter of the wing appears, and only the mediastinal and scapular veins. The outer margin was very straight; the apex broadly rounded and roundly angulate externally. The mediastinal area wide at base reached to the distal sixth of the wing and had numerous simple or forked, oblique, parallel branches. The scapular vein began to fork not far beyond the middle of the wing, and itself straight and running to the tip of the wing, sent four distant and subequidistant branches to the margin, the last two simple, the first two com-

pound, the branches being scarcely more longitudinal than the mediastinal but increasingly so as the apex is gained.

The fragment, Nos. 24 and 64, is 13 mm. long and indicates a wing about 25–30 mm. long, making it much the largest of the Fairplay cockroaches. The color is a uniform dark brown.

Petrablattina Scudder.

This genus, established on forms discovered in carboniferous deposits, proves to be as well developed in the triassic rocks as in the paleozoic series.

Petrablattina aequa.

Pl. 42, fig. 13.

Petrablattina aequa Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 38.

Mediastinal vein terminating scarcely beyond the middle of the costal margin, with numerous, closely crowded, simple branches; scapular vein terminating above the tip of the wing, and beyond the basal curve nearly straight, with four or five singly forking branches; branches of externomedian vein straight, superior, mostly simple, parallel to the main scapular vein; the internomedian area extending to some distance beyond the middle of the wing. It is a tolerably large species, the wing measuring 24 mm. in length and 10 mm. in breadth.

Four specimens were obtained, one however showing nothing but the anal area, Nos. 20, 61, 62, 63.

Petrablattina meieri.

Pl. 42, fig. 17.

Petrablattina meieri Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 38.

Mediastinal vein terminating a long way beyond the middle of the costal border, with comparatively distant, usually simple branches. Scapular vein terminating just below the tip of the wing and beyond the basal curve, gently arcuate throughout, with branches similar to those of *P. aequa*, but occupying a larger area. In consequence, the externomedian area is of less importance than in *P. aequa*, and it has but few branches, which appear to be generally simple, and slightly declivent, though superior. Unfortunately this portion of the wing in the single specimen known is very obscure. The internomedian vein is not preserved in its outer portion, but it evidently reached the border nearer the base than the mediastinal vein, and the anal furrow is strongly curved. The wing is broken at the base, but its probable length was 19 mm., and its breadth, 7mm. It is named after Mr. Robert A. Meier, of Garo, Col., in whose shaft all these specimens were obtained, and who afforded our party all possible assistance in working them.

A single specimen was secured, No. 25.

Poroblattina Scudder.

Poroblattina Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 38–39.

Allied to Petrablattina, and especially the species of that genus found in the same Triassic rocks, differing from them principally in the insignificant part played by the mediastinal area and the corresponding importance of the scapular area. The mediastinal vein extends no further out than the anal, terminating far before the middle of the wing, and has consequently but a few offshoots; while the mediastinal, sweeping downward, away from the costal margin at the termination of the mediastinal, occupies nearly half of the wing before curving upward again to terminate above the apex. The externomedian vein is arcuate and terminates on the lower margin not far from the tip, and has only three or four superior longitudinal branches. The anal furrow is strongly arcuate. The anal veins are nearly parallel to the inner margin, but impinge upon it near the anal furrow.

This genus is peculiar to Fairplay and two species are known.

TABLE OF THE SPECIES OF POROBLATTINA.

Scapular vein strongly sinuous, the proximal series of branches simple	1. P. arcuata.
Scapular vein gently sinuous, the proximal series of branches deeply forked	2. P. lakesii.

1. Poroblattina arcuata.

Pl. 41, fig. 5.

Poroblattina arcuata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 39.

The costal border is considerably convex. The scapular vein is unusually arcuate and has a large number of mostly simple oblique branches. The externo- and internomedian veins, on the contrary, have few and distant branches, and the former is also strongly arcuate. The whole surface of the wing is broken by closely crowded cross-veins, which are more transverse to the whole wing than to the interspaces.

Length of fragment, 5.5 mm.; probable length of wing, 10 mm.; breadth, 4 mm.

A single rather imperfect specimen was obtained, No. 47, indicating a wing well rounded and much shorter in proportion to its breadth than in the next species.

2. Poroblattina lakesii.

Pl. 41, fig. 11.

Poroblattina lakesii Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 39.

The costal border is nearly straight and the wing elongate. The scapular vein is much less arcuate than in the preceding species and has a comparatively small number of distant, singly or doubly forked, oblique branches. The much less oblique branches of the internomedian vein are more frequent but appear less crowded from their simplicity, while those of the externomedian are more distant than the latter, and equally simple. There is no sign of any cross-venation.

Two specimens, Nos. 30, 73 and 74. This species like the preceding, is small, the wing measuring about 12 mm. long, and 4.5 mm. broad. Named after Prof. Arthur Lakes of the School of Mines at Golden, Colorado, the first discoverer of these fossils.

BLATTARIAE Latreille.

NEORTHROBLATTINA Scudder.

Neorthroblattina Scudd., Proc. Nat. Sc. Philad., 1885, 108–109.

In this genus the wings are about two and a half times longer than broad, with fairly well rounded apices, the mediastinal and scapular veins amalgamated into a single vein, which extends nearly to the tip and in the middle of the wing occupies nearly one-half its width. The internomedian vein is of varying importance, and in the large anal area the veinlets terminate on the margin; the anal furrow is strongly arcuate, and deeply impressed.

All the species are small. *N. lakesii* may be taken as the type.

TABLE OF THE SPECIES OF NEORTHROBLATTINA.

Fore wings not more than two and a half times as long as broad; mediastino-scapular vein terminating only a little before the tip of the wing.

Internomedian vein beginning to fork long before externomedian and of equal importance with it. **1. N. albolineata.**

Internomedian vein beginning to fork scarcely or not before the externomedian and of less importance than it.

Internomedian area terminating much farther from the apex of the wing than the mediastino-scapular. **2. N. lakesii.**

Internomedian area reaching out toward the apex of the wing nearly as far as the mediastino-scapular. **3. N. rotundata.**

Fore wings about three times as long as broad; mediastino-scapular area terminating long before the tip of the wing. **4. N. attenuata.**

1. Neorthroblattina albolineata.

Pl. 42, figs. 2, 18.

Neorthroblattina albolineata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 109.

The single wing has lost the tip, but all the essential features are preserved, excepting the form of the tip. The wing is very dark colored, and the veins appear as very pale lines upon it. The costal margin is gently and equably arched, while the inner margin is perfectly straight. The externomedian vein is little developed, first forking and then not widely in the middle of the wing, its fuller development being prevented by the ample and unrestricted development of the internomedian vein, which runs in a full rounded course nearly to the tip of the wing. The anal area is interesting because the veins of the upper half run close to, but do not impinge upon the anal furrow, curving downward just before reaching it, and either running into the next vein below and terminating there, or continuing parallel to the furrow and terminating on the inner border.

A single prothoracic shield has been found which I have referred here. It is broadly transversely oval, considerably domed, highest in a vague, transverse, median ridge, the anterior curve indistinctly bent in the middle (not so shown on the plate), the posterior curve broad and in the middle somewhat flattened; the sides are well rounded and the whole is about a fourth broader than long, all the margins entire.

Length of fragment of wing, 7 mm.; probable length of wing, 9 mm.; breadth, 3.5 mm.; length of prothoracic shield, 3.5 mm.; breadth, 4.3 mm.

Two specimens, Nos. 32, 33.

2. Neorthroblattina lakesii.

Pl. 42, figs. 9, 15.

Neorthroblattina lakesii Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 109.

The costal margin is arched as in the last species, and the inner margin has an almost equal opposite curvature. The externomedian vein has a very sinuous course, and forks before the middle of the wing with abundant neuration, occupying on the margin the entire tip of the wing, and almost the outer half of the lower margin, while the internomedian is reduced to an arching vein, extending but little beyond the anal furrow, and with only two or three branches; the anal veins are all parallel to the anal furrow and simple.

A single stone with its reverse shows the prothoracic shield, which is broadly and transversely oval, a little more than a fifth broader than long, tolerably regular, with very broad sides, the anterior margin scarcely bent in the middle, the curve of the hind margin somewhat flattened; uniformly and rather strongly domed, the lateral margins a little flattened, and with a median, slight, but rather abrupt and pretty large, rounded depression.

Length of fore wing, 9 mm.; breadth, 3.5 mm.; length of prothoracic shield, 3 mm.; breadth, 3.65 mm.

Two wings, one of them with its reverse, and one shield with its reverse, were found, Nos. 34, 35 and 82, 76 and 77. Named after Prof. Arthur Lakes of the School of Mines in Golden, Colorado, who first made known these beds, this species being one of the first discovered by him.

3. Neorthroblattina rotundata.

Pl. 42, figs. 7, 8.

Neorthroblattina rotundata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 109-110.

The costal margin in this species is very strongly arched, while the inner margin is straight, giving a very different aspect to the wing. It closely resembles the preceding species in the mediastino-scapular and anal areas, and also in the peculiarities of the externomedian vein, excepting that the latter does not encroach to so large a degree upon the internomedian, the terminal offshoot of which creeps along the border so as to limit the marginal extent of the externomedian area almost as much below as above, although the branching of the externomedian vein is scarcely lessened thereby.

Length of wing, 8.5 mm.; breadth, 3.3 mm.

Three specimens, all with reverses, Nos. 78 and 79, 100 and 101, 102 and 103.

4. Neorthroblattina attenuata.

Pl. 42, fig. 1.

Neorthroblattina attenuata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 110.

This species departs from the typical forms in its slenderness and pointed apex, but it agrees so fairly in general structure that it would best be placed here. The costal margin is not regularly arched, being flattened mesially, while the whole wing tapers regularly in the apical half; the inner margin is also arcuate, and the tip bluntly pointed. The

mediastino-scapular vein terminates considerably before the apex, and the oppositely arcuate internomedian reaches almost as far out, the branches of both nearly always simple. The anal veins are only slightly irregular.

Length of wing, 12 mm.; breadth, 4 mm.

A single specimen with its reverse, Nos. 31 and 75.

Scutinoblattina Scudder.

Scutinoblattina Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 110.

In this genus, composed of small species, the front wings are decidedly more coriaceous than the hind wings, so that the neuration is often more or less obscured by it. The wing itself is convex, as in the modern Phoraspis, and subtriangular in form, its greatest width being near the base, while the tip is bluntly pointed. The mediastinal and scapular veins are again blended into one which, instead of having a sinuous course, is nearly or quite straight and terminates below the apex of the wing, while the externomedian vein follows closely parallel to it, and the oblique veins of this and the internomedian veins follow each other so as to make it difficult to tell where the line of demarcation may lie. The anal veins sometimes fall on the margin and sometimes on the anal furrow. *Scutinoblattina brongniarti* may be regarded as the type of this group.

TABLE OF THE SPECIES OF SCUTINOBLATTINA.

Mediastino-scapular and externomedian veins having a distinctly sinuous course through the middle of the wing, both terminating below the apex.
- Anal branches falling on the hind margin . . . . . 1. S. brongniarti.
- Anal branches falling on the anal furrow . . . . . 2. S. intermedia.

Mediastino-scapular and externomedian veins taking a straight course through the middle of the wing, both terminating at the tip . . . . . 3. S. recta.

1. Scutinoblattina brongniarti.

Pl. 42, fig. 5.

Scutinoblattina brongniarti Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 110-111.

In this interesting species the wings are very strongly convex at the base, and the whole surface is flecked with dark spots. The branches part from the main veins at a similar angle on either side of the middle of the wing. The anal area extends nearly to the middle of the wing, where it is marked by a considerable emargination, and its veins are frequent, oblique, mostly simple, and terminate on the margin.

One of the specimens shows also a portion of the hind wings and most of the prothorax. The former were longer and considerably broader than the fore wings, but no essential part of the neuration can be traced. The prothorax was transversely ovate, a little angulate at the sides, strongly domed, and either the head or an impression of much the shape and size of a head, about half the width of the prothoracic shield, can be seen lying on the anterior half of the latter.

Length of fore wing, 7 mm.; breadth, 3 mm.; length of prothoracic shield, 2 mm., breadth, 3 mm.

Two specimens, one with reverse, Nos. 36, 80 and 81. Named after Mr. Charles Brongniart of Paris, well known for his remarkable discoveries among the older fossil insects.

2. Scutinoblattina intermedia.

Pl. 42, fig. 4.

Scutinoblattina intermedia Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 111.

This species resembles the last, but is not marked by any dots, and the anal area, while shorter, shows no emargination of the border at its extremity; the anal veins are very close, parallel to the inner margin, and terminate not on the margin, but on the anal furrow. It further differs in that the externomedian branches are considerably more longitudinal than those terminating on the costal margin.

Length of wing, 7 mm.; breadth, 2.75 mm.

Two specimens, one with its reverse, Nos. 97 and 98, 99.

3. Scutinoblattina recta.

Pl. 42, figs. 3, 16.

Scutinoblattina recta Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 111.

This species, the smallest and most abundant of all in the triassic rocks, is rather slenderer than the others, and has the surface finely reticulated. The mediastino-scapular and externomedian veins run side by side in perfectly straight lines from the middle of the base to the middle of the tip, the branches, very few in number, parting similarly on the two sides. The costal is more arched than the inner margin, and where they can be made out, the one or two anal veins seem to run to the margin, but all the veins on the wing are exceedingly obscure.

A couple of stones, one with its reverse, show the prothoracic shield to have been very nearly circular, slightly broader than long, scarcely more produced in front than behind, uniformly and considerably domed, the margins entire and in no way displayed.

Length of wing, 6.3 mm.; breadth, 2.4 mm.; length of prothoracic shield, 2.9 mm.; breadth, 3.1 mm.

Four wings have been found, three of them with reverses, Nos. 37, 85 and 86, 87 and 88, 89 and 90, besides two prothoracic shields, one with its reverse, Nos. 38 and 84, 83.

HEMIPTERA.

Cercopidae Leach.

The remaining insects appear to fall in this group of homopterous insects.

Cercopyllis (dim. of *Cercopis*) gen. nov.

Under this name are grouped the very few insect forms found in these beds which are not cockroaches. They are very small and appear to be quite unlike anything found in mesozoic or older deposits. Hardly anything besides wings are known, and these in all cases fore-wings with extremely simple nenration, consisting of a simple radial vein

terminating in the distal half of the wing after an abrupt bend, an ulnar vein with only a very few branches not connected by cross veins, and one or two simple or simply forked veins in the anal area of the wing.

Cercopyllis justiciae sp. nov.

Pl. 42, fig. 6.

A small stout-bodied insect with a tapering abdomen, divided uniformly into joints and with a somewhat pointed tip. The fore-wing extends a long way beyond the tip of the abdomen, which indeed only reaches its middle, is moderately broad with a strongly and regularly convex costa; the apex is lost, but the curve gives a certain definiteness to the probable length of the wing, so that the radial vein may be said to terminate at the end of its middle third; this vein runs completely parallel to and at a moderate distance from the margin until close to its termination, when it bends abruptly as if to form an ovate stigma and passes obliquely to the margin. The ulnar vein forks thrice subequidistantly, the last time opposite the bend of the radial vein, to the oblique end of which its final branch is parallel; the first fork is a little nearer to the base of the wing than to the last fork, and the vein is rather distant from the radial vein; all the branches are simple, distant, nearly straight, and unconnected by cross veins. Within these are two other simple veins, parallel to the inner ulnar branch, the one next it perhaps the sutura clavi.

Length of (headless) body, 4.4 mm.; breadth of thorax, 2.2 mm.; length of fragment of wing, 5 mm.; probable complete length, 5.4 mm.; probable breadth, 2.1 mm.

A single specimen and its reverse, No. 39.

Cercopyllis delicatula sp. nov.

Pl. 42, fig. 11.

A nearly complete fore-wing unfortunately with the base very obscure. It is about two and a half times longer than broad, broadest in the apical half toward which it increases very slowly in size, tapering more rapidly, the apex well rounded, the upper and lower halves nearly symmetrical, the costal margin nearly straight to the end of the radial vein. The radial vein is very similar to that of the preceding species, but if anything is a little longer. The ulnar vein has the same number of branches, but arising at very unequal distances and so of very unequal lengths, the first and second near together, well within the basal half of the wing, the outer quite as in the preceding species, though a little farther removed from the oblique portion of the radial vein. The vein next within the inner ulnar vein (the sutura clavi?) is straight and not, as shown on the plate, arcuate, and the one within that shows some signs of simple inferior branches. Veins and membrane alike are seen under a half-inch objective to be uniformly clothed with excessively fine hairs, as far apart as their own length (which does not exceed 0.017 mm.), directed outward, with a tendency to run in lines.

Length of wing, 5.2 mm.; breadth, 2 mm.

One specimen and its reverse, No. 40.

Cercopyllis adolescens.

Pl. 42, fig. 12.

A single fragment of the tip of a wing which resembles *C. justiciae* rather than the last species, but in size agrees better with the latter and has the same apical curve. The radial vein comes much nearer to the tip of the wing than in either of the others, and has a decided curve in opposition to the costa just before the final bend. From what can be seen of the ulnar vein, it would seem to be constructed as in the others, but the final fork is earlier and its relation to the preceding and to the oblique end of the radial vein more as in *C. justiciae* than as in *C. delicatula*. Nothing of the other veins can be seen. The membrane and veins are clothed precisely as in *C. delicatula*, though less distinctly, and the hairs appear to be shorter (perhaps more erect) and if anything more distant.

Length of fragment, 3.2 mm.; breadth, 1.4 mm.

One specimen, No. 41.

EXPLANATION OF PLATES.

Plate 41.

All the drawings are by Mrs. Katherine Peirson Ramsay and are magnified $\frac{4}{1}$.

Fig. 1. *Spiloblattina triassica.*
Fig. 2. *Spiloblattina guttata.*
Fig. 3. *Spiloblattina marginata.*
Fig. 4. *Spiloblattina gardineri;* hind wing.
Fig. 5. *Poroblattina arcuata.*
Fig. 6. *Spiloblattina gardineri.*
Fig. 7. *Etoblattina persistens.*
Fig. 8. *Spiloblattina gardineri.*
Fig. 9. *Anthracoblattina triassica.*
Fig. 10. *Spiloblattina gardineri.*
Fig. 11. *Poroblattina lakesii.*

Plate 42.

The drawings as on the preceding plate.

Fig. 1. *Neorthroblattina attenuata.*
Fig. 2. *Neorthroblattina albolineata.*
Fig. 3. *Scutinoblattina recta.*
Fig. 4. *Scutinoblattina intermedia.*
Fig. 5. *Scutinoblattina brongniarti.*
Fig. 6. *Cercopyllis justiciae.*
Fig. 7. *Neorthroblattina rotundata.*
Fig. 8. *The same.*
Fig. 9. *Neorthroblattina lakesii.*
Fig. 10. *Etoblattina persistens.*
Fig. 11. *Cercopyllis delicatula.*
Fig. 12. *Cercopyllis adolescens.*
Fig. 13. *Petrablattina acqua.*
Fig. 14. *Spiloblattina guttata;* hind wing.
Fig. 15. *Neorthroblattina lakesii;* prothoracic shield.
Fig. 16. *Scutinoblattina recta;* prothoracic shield.
Fig. 17. *Petrablattina meieri.*
Fig. 18. *Neorthroblattina albolineata;* prothoracic shield.
Fig. 19. *Etoblattina persistens;* prothoracic shield.
Fig. 20. *Etoblattina* sp.

XIII. Fusion of Hands.

By Thomas Dwight, M. D., LL.D.

Parkman Professor of Anatomy at Harvard University.

[Read April 20, 1892.]

Cases of polydactylism in which the increase of the number of fingers clearly springs from the fusion of two more or less complete hands and forearms are extremely uncommon. There are several, for the most part rather imperfect, accounts of this condition as seen in living persons, or in undissected specimens, or recorded in the plates of old authors, but there seems to be no dissection like the one about to be described in any museum, nor any description of a similar dissection in literature. This one, indeed, was described forty years ago by Harvard's distinguished Professor of Morbid Anatomy, the late Dr. J. B. S. Jackson, but the dissection had not been carried far enough to show some of the most important features, the account was inadequate, and in parts wanting in the anatomical accuracy which is so essential, but can hardly be expected from any other than a trained anatomist. Moreover the account appeared merely in an abstract of the Proceedings of the Boston Society for Medical Improvement which was published in the American Journal of the Medical Sciences, Vol. XXV, January, 1853, p. 91. It is practically buried. It is indexed in the Journal as "Malformation" without any qualification whatever. Thus this most remarkable case is not mentioned by the most exhaustive writers on the subject. The specimen originally belonged to the Cabinet of the Boston Society for Medical Improvement which some years ago came into the possession of the Harvard Medical School. It seems proper to bring it forth from the obscurity in which it has remained so long, especially as it is particularly valuable in connection with a recent observation on the living by Dr. F. Jolly of Berlin.

A preliminary glance at the bibliography will help to the better appreciation of this case. The literature is far from satisfactory. It is all the more obscure from the diversity of interpretations and from the difficulty which often exists in deciding in which class a particular case belongs. The following seem to be undoubted cases of the fusion of two more or less perfect hands. In some of these cases we have no question that the fusion extends into the forearm and even beyond the elbow.

1. Rueff. *De Concepta. Frankfurt.* 1587. *Plate* 41. In the text it is stated that there are twelve fingers but, according to Morand and to Taruffi, the plate shows a child having two hands joined by the ulnar side, each with five fingers. There were also double feet.

2. Ambrosini in Aldrovandi. *Monstrorum Historia. Bonn*, 1642, *pp.* 495 *and* 497. A foetus with two hands on each arm with five fingers each and joined on the ulnar side.

3. Kerkring. *Observat. Anat. Amsterdam.* 1670, *p.* 15, *Obs. XX, with plate.* A skeleton of a boy with seven fingers on each hand of which the longest were in the middle. On the right there were seven metacarpals but a thumb could not be recognized. On the left hand there were apparently five metacarpal bones. The first phalanx of the thumb arose on the outside of the 7th finger. One foot had eight toes and the other nine. [This is on the authority of Taruffi. It seems the least certain of these cases.]

4. Du Courai. *Journal des Savants.* 1696. An infant with eight fingers on the right hand, of which the two indices were joined together as well as the two little fingers. [It is not easy to see how this could occur unless the hands were put face to face.] There were seven fingers on the left hand of which the indices were joined and the rest separate. It seems from the context that there were no thumbs. Both hands were bent inwards on the wrists and could not be extended. The metacarpus was a third longer than usual. Each foot had seven toes, of which the great toes of each foot were united. The head was monstrous.

5. Giulio Obsequente. *Grammatico Latino. De prodigiis.* A girl with four hands and four feet.

6. Wirtensohn J. *Dissertatio. Berlin*, 1855. A human monster with four hands and four feet in the Berlin Museum. [Taruffi, from whom this reference is taken, states that he was not able to verify this observation.]

7. Murray. *Medico-Chirurgical Trans. Vol. XLVI, London*, 1863. This is a very noteworthy case especially in connection with the one which is the subject of this paper. A woman, thirty-eight years old, living at Brighton, had two hands of four fingers each on the left arm, united at the radial side. "The fingers of both hands are clubbed at their tips. The middle and ring fingers of the supernumerary hand are webbed as far as their proximal joints and the movements of the fingers of this hand are somewhat stiff and imperfect. The thumbs seem to be represented only by the prominence on the dorsal surface seen in figure 3." This is a very poorly shown little projection apparently on the back of the proximal phalanx of the index of the normal hand. [It may be advisable to point out that when, as in this case, we have two hands united by corresponding sides, one of them must be a right hand and the other a left hand. The one which is of

the same side as the arm is the normal hand; the other the extra one.] The two sets of fingers could be opposed to each other. It seems that the woman when at work scrubbing the floor rested on the back of the flexed carpus. Mr. Murray says: "From the rigidly arched conformation of the metacarpal portion of the double hand, it is evident that she could not lean on the palm." The woman was otherwise well-formed. There was nothing of the kind in her family as far as she knew, and she had a normal child. The rest may be given in Mr. Murray's own words. "The shoulder joint is natural. The external condyloid ridge of the humerus is strongly defined. The elbow joint may be fully extended, but flexion cannot be carried further than is represented in Fig. 1." [say to an angle of 120° with the humerus] "and the impediment seems to be the unusually large coronoid process of the ulna. The muscles and tendons of the forearm are so prominent that it is not easy to decide whether there is a second radius or ulna; but after numerous examinations made under favorable circumstances, I feel sure that the duplicity of bony structure begins at the carpus. Pronation and supination are freely performed." It will be necessary to review these statements in the light which the present case throws on the internal structure of the forearm.

8. Giraldes. *Maladies Chirurgicales des Enfants.* A case of a child's hand with eight fingers in two sets and no thumb.[1] A clear case of two nearly perfect hands fused at the radial sides. Giraldes refers to two similar specimens which, having injected and dissected, he placed in the *musée de l'amphithéâtre des hôpitaux.* Of these Fort[2] says in 1869. "*Nous ne les avons pas trouvées.*

9. Giraldes. *Bull. Soc. Chirurg. Noc.* 1865. M. Giraldes said: "I have had an opportunity to see in my service a case of two entire hands on a single forearm. M. Guersant has seen the same person."

10. Fumagalli. *Sulle deformità congenita della ditta. Annali Univ. di Med. Milano. Vol. CCXVI. p.* 305. 1871. A girl of four months without family predisposition had the right hand with eight fingers and no thumb. The two sets were united by the radial side. The double hand was anchylosed at a right angle to the forearm. The extra fingers had less motion than the normal ones. Their metacarpal bones were incomplete.

11. Kuhnt. *Virchow's Archiv. Band LVI,* 1872. A German recruit twenty-one years old. Each hand consists of the ulnar half of two hands fused. The left hand consists of five fingers and no thumb. Three of the fingers apparently are of the left hand to which are added the ring and little fingers of a right hand. The right hand is less symmetrical. There are the three normal fingers of the ulnar side to which are added two fingers and a rudiment of a third of a left hand. According to the drawing, there is no abnormal flexion.

[1] This is the case erroneously attributed to Lanceraux in Ziegler's Lehrbuch der pathologischen Anatomie, 1892.

[2] Des difformités congénitales et acquise des doigts. Thèse, Paris, 1869.

The man was a workingman, and it is stated could do only coarse work (grobe Arbeiten). Nothing is said of the motions of the elbow.

12. Gerrhini. *Gazetta Med. Ital.-Lombardo.* No. 51. 1874. A boy five years old had six fingers on each hand divided into two groups. It is a clear case of the fusion of the ulnar sides of two hands.

13. Langalli. *La scienza e la pratica. Pavia*, 1875. An account of a wax model of a girl's right hand found in a museum. Four fingers of three phalanges represent the normal hand. The other four represent the absent thumb. Again there seems no doubt that this is a case of fusion.

14. F. Jolly. *Festschrift, Rudolf Virchow gewidmet. Band I. Berlin*, 1891. This case is the most important one. The individual presenting the peculiarity was a living man, twenty-five years old, without hereditary predisposition, but of peculiar and deficient mental organization. The deformity was on the left arm, which from the shoulder down was smaller and shorter than the right. The fingers were in two groups of three, each consisting of a middle, ring, and little finger. The fingers of the group on the outer, or radial side, were those of a right hand. One proximal phalanx of the extra set was broad at its base so as to articulate with two metacarpal bones, of which there were seven in all. The internal condyle of the humerus and the normal ulna were easy to feel. There was no distinct external condyle and no head of the radius could be made out. Along the front of the humerus in the region where the biceps should be "there is felt instead of that muscle a strong bony ridge which runs to the bend of the elbow and ends in a blunt prominence." As well as could be judged on the living, it would seem as if on about the lower two thirds of the humerus there was an outgrowth, or another bone fused with it on the front and outer side. The outer bone of the forearm feels at the wrist more like an ulna than a radius. The man can raise his arm at the shoulder but little above a horizontal line. It can, however, be brought passively to a vertical position. The photograph shows a flattening in the deltoid region. The elbow can be flexed actively only to an angle of about 150°. Passive flexion does not exceed 120°, the above mentioned bony process locking the joint. There is next to no pronation and supination. The hand can be both actively and passively flexed and extended. So can, also, the fingers either individually or in groups. The photograph shows a tendency to flexion and pronation of the hand which the author does not mention. Dr. Jolly thinks one would be inclined to believe that the ulnar parts of two hands and two forearms had been fused together while the radial constituents had in part been lost. He says that whether his interpretation, made on the living, is the correct one will be shown certainly when there is a chance to examine an analagous case.

It should be noticed that of the preceding cases in 1, 2, 5, 6, and 9 there are two practically complete hands. In cases 1 and 2 (if there be no mistake) these are joined on the

ulnar side. The point is not mentioned in cases 5, 6, and 9, which are of little value. Case 3 is unsatisfactory. It is certainly allowable to question whether the phalanx growing in one case from the seventh finger is rightly called the thumb. If it be not a thumb this case may be considered the result of the fusion of the ulnar portions of two hands. Case 4 is also wanting in clearness. This leaves cases 7, 8, 10, 11, 12, 13, and 14 showing fusion of the ulnar parts of the hands with suppression of more or less of the radial parts. For reasons which will appear later it is probable that in several of these, the duplication of one side and the suppression of the other are not limited to the hand.

The next case is placed last, out of the chronological order, because, though the polydactylism is also due to the fusion of a part of an extra hand, it differs extremely from the others.

15. Carré. *Séance publique de la Société Royale de Médecine, Chirurgie, et Pharmacie de Toulouse.* 1838, *pp.* 28-30. A goldsmith had on his right arm, beside the normal hand, an extra thumb and index finger. The latter thumb was next to the normal one and the index further from it showing that of course they belonged to a left hand. Indeed the two thumbs were united and had, according to Carré a common metacarpal joint. They were of equal size. They were flexed and extended together and had the power of spreading apart. The next finger arising from the outer side of the thumb was shaped like an index and had free motion in flexion, extension, and abduction. Besides the radius and ulna of the normal arm there was an extra radius on the outer side of the former, joined to it at the wrist, but separated from it above by an interval that could be felt. It had a joint of its own at the elbow. The motion of each bone could be felt, though pronation was impaired. The wrist was broad, implying the presence of additional bones. Nothing is said of a metacarpal bone for the new index.

The present specimen is the left arm of a German machinist thirty-seven years old who died of chronic diarrhoea at the Massachusetts General Hospital in Boston in March, 1852. The arm was dissected by the late Dr. Ainsworth and made into an old-fashioned dried and varnished preparation showing most of the muscles of the upper extremity and the chief arteries and nerves of the forearm and hand. The parts, of course, are much shrunken and distorted, but the specimen has kept unchanged. There is no account of any deformity excepting of the left arm. From a hint in the Hospital Records and from an anecdote told by a physician who remembered him, it may be inferred that the patient was of loose morals and of a peculiar temperament, which is recorded from the similarity to Dr. Jolly's case. Figures 1 and 2 of plate 43 represent a cast taken after death which also is in the Museum of the Harvard Medical School. It shows a left forearm and a very broad hand having four normal fingers and, in place of the thumb, the three inner fingers of a right hand which were smaller than the others. The hand is flexed and somewhat pronated.

The dissected specimen is in much the same position but less strongly flexed. The carpus and metacarpus are arched transversely so as to form a deep hollow in the hand. Dr. Jackson said in his report of the case to the Boston Society for Medical Improvement in the summer of 1852: "the hand was not merely very useful to him in the way of his business, but gave him some advantages, he thought, in playing upon the piano, upon which instrument he was a performer. The three upper fingers, supposing the hand to be laid in a state of semipronation, were used efficiently as a thumb to oppose the three[1] others. Various observations were made upon the motions of the hand and fingers." Unfortunately these were not recorded in the hospital records and no notes bearing on them can be found among Dr. Jackson's papers. The left arm was shorter than the right. Dr. Jackson gives the length of the left forearm as $8\frac{1}{2}$ inches and that of the humerus as 10 inches, the right ulna measuring nearly 10 inches and the humerus 13 inches. The scapula (Plate 43, fig. 3) is very peculiar. The supra-scapular notch is broad and so deep as to pass below the spine. The spine is so slanted that what is called the upper surface of the acromion looks almost directly outward. It is moreover very slight. The supra-spinous fossa is rudimentary. Its anterior portion is wanting and most of the posterior part of the floor is convex instead of concave. Dr. Jackson had perfectly recognized that the bones of the forearm were two ulnae, and that there was no radius; but the parts about the elbow were so hidden by the dried muscles that very important features could not be made out. I therefore had the specimen photographed before it was disturbed and rewrote the description of the soft parts. Then softening the dried muscles by a steam of almost boiling water I examined thoroughly the bones at the elbow and finally separated the arm from the forearm. The bones were then photographed. The wrist and hand were not further dissected as the preparation gave a good view of the dorsal aspect of the carpal bones.

The Bones. The forearm consists of the normal left ulna and of a right one in the place of the radius. The left one shows little that calls for comment, excepting that there is a projection outward at the place of the lesser sigmoid cavity to join a corresponding projection from the other ulna. The upper surface of this projection articulates with the humerus. At the lower end the styloid process is less prominent than usual, and the head rather broad. The right or extra ulna is put on hind side before, that is the back of the olecranon projects forward over the front and outer aspect of the humerus. If the reader will place his right forearm on the outer side of the left one he will see that it is necessary for the ulna to be thus inverted if the thumbs are to touch and the palms to be continuous. This olecranon is thinner, flatter, and longer than normal. The coronoid

[1] Dr. Jackson says "three" instead of "four" as he looked on the normal index as a central finger with three on either side of it—a view to which I cannot agree, though it has some support in the plan of the extensor tendons.

process is rudimentary. From the side of this process and from the shaft just behind it arises the projection already referred to which meets a similar one from the normal ulna. (Plate 43, figs. 4, 5.) On the front of this there is a small articular surface looking forward which suggests a part of the convexity of the head of the radius. (Plate 44, fig. 1.) The upper articular surface shows a fissure separating it from the side of the olecranon which is not found in the normal ulna. These projections which touch each other are held together by a strong interosseous ligament. The lower end of this ulna is very like the other only somewhat broader. The mode of union of the lower ends could not be seen without unwarrantable injury to the specimen. There can hardly have been any definite movement between these bones. Perhaps the ligaments may have permitted some irregular sliding, but it is impossible to know. These bones have been described first because their nature is very clear and, once understood, is a key to the more difficult interpretation of the lower end of the humerus.

The upper end of the humerus, concealed as it is by dried muscles, presents nothing noteworthy. There is no roughness for the attachment of the deltoid though the place for it is exposed. At the lower end the internal condyle is normal. It is quite unmistakable and is the most evident starting point. On the posterior surface is an olecranon fossa containing the normal olecranon. Beyond this is a thick rounded swelling, which, however, can hardly have been prominent before dissection. This is the normal outer condyle of the humerus *plus* another of a right humerus applied to the normal bone at nearly a right angle. A prominence somewhat to the outer side of the front of the normal humerus represents the internal condyle of the right one. Between this and the fused external condyles is the joint for the right olecranon. There is but a faint trace of a fossa above it. Between the two internal condyles is a very small coronoid fossa on the front of the normal humerus. (Plate 43, fig. 4; plate 44, figs. 2, 3.) Thus it appears that to this left humerus is added a part of the lower end of a right one, so applied that the outer condyles are fused and the right inner condyle projects forward. To illustrate this I have made a model (Plate 44, fig. 4), by sawing off obliquely a great part of the outer condyle of a left humerus and applying to it a part of the lower end of a right humerus cut in the same way. Each humerus bears its own ulna. If the lateral expansions from the side of the coronoid processes and of the shaft behind them could be put on this would represent strikingly the relation of the bones at the elbow.

The dorsal side of the carpus was well exposed in the original dissection but the description was not anatomically correct. The palmar aspect cannot be studied. The carpus is so convex that it is not possible to get a satisfactory photograph. The relations of the bones are shown in the diagram in which they are represented as in a level plane. The proximal row consists of three bones besides the two pisiforms. At either side of the wrist is a cuneiform (*os triquetrum*), the dorsal

surface of which is uncommonly large. Between them is a bone which evidently is the result of the fusion of two semilunars. Its upper border is slightly notched. The pisiforms in the tendons of the ulnar flexors are displaced above the wrist on to the ulnae. Extension of the hand would have brought them on to the cuneiform bones. At each end of the second row there is an unciform bearing the little and ring fingers. Each rests on the corresponding cuneiform and touches the semilunar. Next come the two ossa magna, very symmetrically disposed, each bearing the metacarpal bone of the middle finger. Their anterior halves diverge so as to leave an interval between them, behind which they touch each other. their heads resting side by side in the middle bone of the first row. In the notch between these bones is the trapezoid (*os multangulum minus*) bearing the left index finger. Each middle finger touches it, the extra one by a broader surface than the normal one of the left hand. Still it is very symmetrically placed, so that from a view of the carpus alone it would be very hard to say to which side it belongs, but a glance at the specimen or at the cast is enough to show that the index finger belongs to the left hand. The metacarpal bones and phalanges require no special description. Those of the extra hand are somewhat smaller than the normal one.

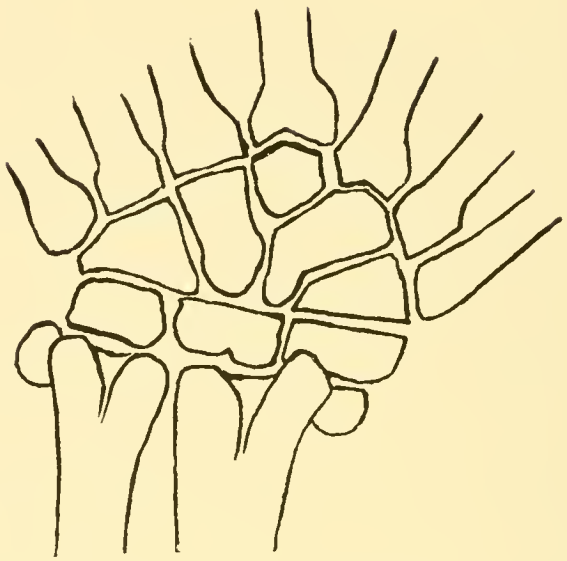


DIAGRAM OF THE DORSAL ASPECT OF THE WRIST.

The Muscles. In this account Dr. Jackson's description is followed as closely as possible. "The tendons of the *latissimus dorsi*, *teres major* and *minor*, *subscapularis*, *infraspinatus*, *pectoralis major* and *minor* are shown in the preparation." No mention is made of the *supraspinatus*. It has been stated that its fossa is rudimentary, if present at all it must have been very small. Dr. Jackson says that the *deltoid* had been removed. The absence of the roughness for its insertion and the lightness of the spine of the scapula and the acromion have been noted. These facts imply that it was small; an interesting point to be returned to later. "*Coraco-brachialis* small." The *biceps* is obscure. There seems to be a small long head with probably a short head from the coracoid joining it low down. The long head is tendinous in the middle of the arm. This muscle is inserted into the extra

internal condyle on the front of the humerus and perhaps also into the bone above it. "One *triceps* sufficiently developed, with its three heads, and inserted into the perfect ulna. A second *triceps*, however, exists which is quite imperfectly developed; one head arises from just below the head of the humerus . . . . . and a second from the lower part of the humerus. It is inserted into the imperfect olecranon but sends a tendon to the corresponding inner condyle, and receives a large slip from the other *triceps*; in structure it is muscular at each extremity and tendinous midway. A supernumerary slip of muscles," appears through the capsule of the shoulder joint, like the long head of another *biceps*, "passes under the tendon of the *pectoralis major* and is inserted into the" extra internal condyle. "There was no well defined *brachialis anticus*."

"In the forearm the muscles usually connected with the radius and thumb are of course wanting. The superficial flexor of the fingers arises from the inner condyle corresponding to the perfect ulna; and sends a tendon to each finger, excepting the little finger of the imperfect side" [*i. e.* of the extra hand] "also a slip from the tendon of the index finger to the deep-seated tendon of the same." The deep flexor arises in two parts. That for the normal hand arises chiefly from the normal ulna, partly from the interosseous membrane. The portion for the index has its muscular belly to a great extent separate from the rest. The part for the extra fingers arises almost if not quite exclusively from the inverted ulna. The little finger has only a small slip given off from the side of the tendon to the ring finger. "*Flexor carpi ulnaris* well developed on the perfect side, but on the other indistinct." This indistinctness probably applies to the muscular belly, for the tendon is perfectly plain, and about as large as the normal one. Each goes to the pisiform bone and probably further. The second one seems to arise from the fibrous or muscular expansion at the outer side of the forearm near the inverted olecranon. No mention is made of a *palmaris longus* but a prominence in the cast indicates that it existed. "*Pronator quadratus* quite well marked, and also the *interossei*." There is a slip of muscle or fascia, now dried and shrunken, running from the muscular mass below the internal condyle to the inverted ulna just below the elbow, strongly suggesting a rudimentary *pronator radii teres*.

The system of the extensors is very complicated, and owing to the distortion of the dried muscles, not easy to make out perfectly. Still a good deal can be added to the original description. No *extensores carpi ulnares* are found, nor is there any mention of them. They probably existed, however, as the groove for the tendon is slightly marked at the lower end of each ulna. A muscle, which may represent one of them, runs along the outer border of the forearm. It springs from a muscular mass on the free edge of the inverted ulna and is inserted apparently into the outer side of its

head sending a small slip to the base of the little finger. No such muscle has been preserved on the normal side. The common extensors of the fingers may be described as follows: A fleshly mass arises from the outer side of the normal olecranon, between it and the fused outer condyles, which sends extensor tendons to the four normal fingers. The one to the index is very small and soon separates from the others. There are the usual cross connections over the metacarpus between the tendons of the inner three fingers. An *extensor proprius indicis* arises from the middle of the ulna and the interosseous membrane. The extensor of the extra hand arises partly in common with the other from the fused outer condyles and partly from the region of the inverted olecranon. It sends tendons, more or less fused, to the three extra digits and a small slip to the index of the normal hand which joins near its insertion the tendon of the *extensor proprius indicis* already mentioned. There arises also from the back of the inverted ulna and perhaps from the interosseous membrane a second *extensor proprius indicis* which is very much the largest of the four extensor tendons going to that finger. The next largest is the *extensor proprius* of the normal hand. There arises also from the back of the inverted ulna near the wrist another small muscle with a tendon going to the back of the middle finger of the extra hand. Near this, but still lower, was another small muscle, the tendon of which had been cut near the base of the metacarpus.

The Arteries. The brachial divides at about the junction of the middle and lower thirds of the humerus. The main continuation, which is the ulnar proper, runs deeply under the band thought to represent the *pronator radii teres*, to the deep part of the forearm where it gives off the interosseous. Above the elbow there is a branch running backward between the internal condyle and the olecranon. The interosseous branches are not easy to trace. There seems to be an anterior interosseous and three branches on the back of the forearm, one running on the membrane and one along each bone. At least two of these share in a network on the back of the carpus. Having reached the hand the ulnar artery runs obliquely across the palm to the cleft between the two sets of fingers, supplying the four normal fingers and the nearer side of the extra middle finger. (Plate 44 fig. 5.) The other branch of the brachial crosses the median nerve and runs, apparently superficially, to the outer side of the forearm. It supplies the little and ring fingers and the corresponding side of the middle finger of the supernumerary set. There is no anastomosis in the palm between the superficial branches of the two arteries. Each gives off a deep branch at the usual place, which forms a deep palmar arch from which some interosseous arteries spring. There is also an arterial network over the front of the carpal bones. The arteries of the deep parts of the hand cannot all be seen.

The Nerves. The ulnar nerve proper, pursues a normal course and supplies the palmar aspect of the little finger and half the ring finger of the normal hand. Near the

wrist it gives off a very small posterior branch, which is not well preserved but which seems to have had less than the usual distribution.

The median nerve is normal as far as the elbow, running to the inner side of the extra internal condyle. It is then lost in the dried fibers of the *flexor sublimis*, from which it emerges in two main divisions near the middle of the forearm. The inner of these soon divides into two, of which one supplies the adjacent sides of the ring and middle fingers and the other those of the middle and index fingers of the normal hand. The outer division of the median supplies the outer side of the index and both sides of the extra middle finger and one side of the extra ring finger. One of the branches to the index gives off a dorsal branch, and there is a doubtful one for the extra middle finger. The musculospiral nerve passes behind the humerus as usual. A nerve which is undoubtedly continuous with it emerges from the hardened muscles over the fused outer condyles. It seems to be the radial branch changed into an ulnar. It runs with the extra ulnar artery to the hand, and sending a deep branch into the palm, goes to the little finger. Its continuation is plain along the side of the little finger nearest to the ring finger. There is a detached branch on the other side of the little finger which in all probability came from it. The deep branch sends a twig along the metacarpal bone of the ring finger. It probably supplied the side of the ring finger left unprovided for, but this is uncertain. Assuming this to have been the case, each ulnar nerve supplies the palmar surface of one finger and a half, the median supplying the remaining fingers of both hands. Unfortunately no dorsal branches except those mentioned have been preserved.

Precisely of what nature and how extensive the movements in this extremity may have been is not easy to determine, but certain main facts are pretty evident. It is very probable from the structure of the spine of the scapula and the want of a deltoid ridge on the humerus that this muscle was a weak one. It is certain that the joint at the elbow allowed but a very limited amount of flexion. There can have been no true pronation and supination whatever, though some irregular movement of the two ulnae on the humerus may have been possible. The cast with the strong cords at the front of the wrist, made probably by the ulnar flexors of the wrist and the *palmaris longus*, seems to show conclusively that the hand was habitually flexed on the wrist and that no great extension can have been possible. The movements of the carpus are entirely a subject for speculation. It seems probable, however, that they were very free in various directions. Pronation and supination were doubtless performed at the shoulder and wrist, with the help of some change in the amount of extension at the elbow aided by vague lateral movements.

A very curious feature of this extremity is the evident attempt of the extra ulna to

imitate a radius. On the front of the projection of the coronoid process is a surface resembling a part of the head of a radius and the lower end is broader than that of the ulna proper. Evidently the bone which developed as a supernumerary ulna made, so to speak, an effort to adapt itself to the functions of a radius.

It is curious also to notice the change in the arteries from the normal type. Thus the brachial after a high division gave off an ulnar which runs deeply and gives origin to the interosseous, as is natural. The other branch runs at first superficially like a radial and then changes into an ulnar giving, as does the other, a characteristic deep branch to the palm.

Still more curious is the origin from the musculo-spiral nerve of a branch in the place of the radial which becomes an ulnar.

We now come to the most important part of the discussion, namely, to the resemblance of the best described of the cases of this deformity to each other. It is more important than the aetiology, for any prospect of solving that question is extremely remote, while there is reason to hope that this dissection will serve as a clue to some of the cases already described. We shall now take in turn several of the features of this case. The one with which it shows a very striking resemblance is that recently reported by Jolly. In both the persons were German males and in both the deformity was on the left side. Dr. Jolly's patient was of a peculiar mental and moral organization. There is some (but not conclusive) reason to think that the same could be said of this individual. In Dr. Jolly's case there was flattening in the deltoid region and an inability to raise the arm above a horizontal line. The scapula is peculiar in this case and there is indication of weakness in the same region. In both cases the affected arm was shorter. What can be felt about the elbow in Jolly's case agrees almost perfectly with the conditions of this one. Dr. Jolly states that where the *biceps* should be there is felt a strong bony ridge ending in a blunt prominence. This is the supernumerary internal condyle which may have had a stronger development than in this case. It is perhaps not impossible that the strong muscular or tendinous band running to it may have given the impression that the bone extended higher than was really the case. The restriction of angular motion and the almost complete absence of pronation and supination give strong confirmation of the similarity of the joints. The photograph shows something of a tendency to flexion and pronation of the hand at the wrist, which Dr. Jolly does not allude to, but it certainly is far less marked than in this case. It is hardly possible to doubt that, except in the condition of the wrist, the cases were similar in all important respects. It is not easy to guess what relation there can be between want of development of the shoulder muscles and this malformation of the hand and arm; but the simultaneous occurrence of these conditions in two cases cannot be regarded as accidental.

Mr. Murray's case is less fully reported and seems somewhat difficult to class with

these two, but I believe it belongs with them. In two respects the case agrees with the present one: flexion at the elbow is very limited, and when working on the floor the woman supported herself on the back of the flexed carpus. This suggests a flexed position of the hand. The metacarpus was also, as in this case, strongly arched. Mr. Murray says that after many examinations he feels sure that the duplicity begins at the carpus. This means that there is no third or fourth bone in the forearm. It implies no reflection on him, to say that the idea of there being two ulnae and no radius may never have occurred to him. He finds a bony impediment to flexion at the elbow which he thinks is an unusually large coronoid. But such a malformation is, so far as I know, unheard of. Is it not more plausible in the light of these observations to believe that the obstacle was the supernumerary internal condyle or perhaps the inverted olecranon? Pronation and supination, he says, were freely performed. This is certainly a very serious difficulty. One might question, however, in the first place whether "freely" is equivalent to "perfectly"; and it must be remembered that to one not very much on his guard these movements are very deceptive. The part played by the shoulder is greater than is often believed. It is moreover not impossible that the articular surfaces at the elbow may have been such as to allow a certain amount of irregular motion, which with the aid of the shoulder and wrist joints, may have permitted a fair amount of twisting of the hand. With all respect to Mr. Murray I can but think it most likely that the forearm consisted of two ulnae.

In the cases of Du Courai and of Fumagalli (Nos. 4 and 10) the hands could not be extended. As has been already pointed out, seven of these cases showed fusion of the ulnar sides of the hands with more or less suppression of the radial sides. The descriptions of most of the cases are very inadequate. Many of them are in children, in whom perhaps a want of the proper motions of the elbow would be more easily overlooked. It is probably more likely that such an oversight occurred, than that cases in which the hands were evidently fused, as in this specimen, should have had forearms of the normal structure. The chief importance of this observation is that in connection with Dr. Jolly's case it goes far to establish a type of a certain kind of polydactylism resulting from the fusion of the ulnar portions of two hands. As has been pointed out, in all the cases recorded in this paper, in which there is any statement of the fact, the fusion was of the ulnar portions of the hands, excepting in cases 1 and 2 and in 15, the remarkable observation by Carré, in which there was an additional thumb and forefinger and an extra radius. It is to be noticed in all these cases, which are at all adequately described, that the hands are fused by corresponding sides. There is no instance of the ulnar side of one hand being joined to the radial side of the other.

The question as to the cause and the process of production of this deformity is very interesting but very obscure. The theory that amniotic folds may have caused a muti-

lation, probably a splitting, which is followed by an attempt at duplication, is at first sight a very attractive one. Certain experiments on lizards' tails give it support from analogy. It accounts for cases in which the lesion was so slight that but a part of one finger is involved, or so deep as to affect a whole extremity. There are, however, certain very serious difficulties. What, it may be asked, becomes of the parts that should form the radial side of the hand in a case like the present one? Another difficulty is that in a large proportion of the cases both hands and both feet are affected. Zander[1] argues that there is no impossibility in the occurrence of symmetrical lesions by the amnion. In support of his views it may be stated that very often, perhaps usually, these malformations of both sides are not absolutely symmetrical, and therefore the more likely to have such an injury for their proximate cause. If these objections can be met this seems the most promising theory. Taruffi, while admitting our ignorance, speaks of "exaggerated gemmation," which conveys no explanation. All are now agreed that there is nothing to be said in favor of a double germ. It is remarkable that this view should have survived so long. A century and a half ago M. de Mairan[2] wrote on this subject: "Il faut dévorer bien des prodiges, lorsque on dit du bout des lèvres que la formation des monstres peut être expliquée par la confusion des germes."

DESCRIPTION OF PLATES.

The following letters have always the same significance. E, the fused external condyles; I, the normal internal condyle; I_2, the extra internal condyle; O, the normal olecranon; O_2, the extra olecranon.

PLATE 13.

1. Cast of forearm and hand, showing the back of the elbow and the palm of the hand.
2. The same cast, showing the back of the hand.
3. The scapula and upper part of humerus.
4. Back and outer side of elbow.
5. Front of elbow.

PLATE 14.

1. Front of the upper end of the ulnae. R indicates an articular surface on the front of the extra ulna simulating a part of a radius.
2. Lower end of the humerus seen from below. The anterior surface is above.
3. Lower end of the humerus seen from the outer side.
4. A model, showing the nature of the malformation. The piece of the extra humerus should, perhaps, have been put on so as to form more nearly a right angle with the left humerus.
5. The front of the wrist and hand. U A, ulnar artery; U A_2, extra ulnar artery; U N, ulnar nerve; U N_2, extra ulnar nerve. M, M, branches of median nerve.

[1] Virchow's Archiv, Bd. 125, s. 479 and 480. 1891.

[2] Hist. Acad., 1742.

XIV. A Bibliography of Vertebrate Embryology.

By Charles Sedgwick Minot.

[Read April 20, 1892.]

The following list of authorities was prepared originally to assist me in the compilation of my "Human Embryology." It contains only such titles as have been verified. In the work of verification I have had repeated assistance from Dr. J. S. Billings; otherwise I have depended chiefly upon the libraries of Boston and Cambridge, which collectively offer facilities to students of science, which are perhaps unsurpassed.

The titles are grouped by subjects, and the subjects are alphabetically arranged. The classification is in many cases necessarily arbitrary, yet I hope it will prove of material assistance to others. A list of subjects is prefixed, and an index of authors added, to facilitate reference to the bibliography.

It is particularly requested that any errors or omissions discovered in this list be communicated to the author, in order that they may be inserted in a supplement which it is proposed to issue later.

SUBJECT INDEX.

Allantois....1-20
Amnion....21-47
Amniotic fluid....48-57
Amphibia....58-85
Amphioxus....86-94
Annelids....95-96
Anus....97-106
Aorta....107-117
Archenteron....118-121
Arteries....122-124
Atavism....125

Biogenesis....126
Birds....127-138
Birth....139-143
Bladder....143A-143E
Blastopore....144-153
Blood....154-254
Blood vessels....255-278
Bone....279-309
Brain....309A-369

Cartilage....370-383
Cells....384-423
Cell division....424-461
Cerebellum....462-465
Cervical sinus....466-467
Coelom....468-476
Conjugation....477-481
Connective tissue....482-501

Decidua....502-529
Dermis....530
Diaphragm....531-540

Ear....541-583
Elasmobranchs....584-598
Elastic tissue....599-601
Epidermis....602-640
Evolution of man....641-697
Eye....698-759

Face....760-764
Fat....765-776
Foetal membrane....777-817

Ganglia....818-826
Ganoids....827-835
Gastrula theory....836-841
General works....842-928
Genitalia external....929-937
Germ layers....938-1025
Gestation....1026-1027
Gills....1028-1029
Gillclefts....1030-1054
Glands....1055-1056
Growth....1057-1068

Hairs....1069-1077
Head....1078-1086
Head kidney....1087-1098
Heart....1099-1127
Heredity....1128-1153
Human embryo....1154-1210
Hybrids....1211-1213
Hypophysis....1214-1222

Impregnation....1223-1299
Intestine....1300-1319
Invertebrates....1320-1356

Joints....1356A-1358

Kidney....1359-1372

Larynx....1373-1378
Leucocytes....1378A
Limbs....1379-1414
Liver....1415-1417
Lungs and trachea....1418-1427
Lymphatics....1428-1434

Mammae....1435-1450
Mammals....1451-1544
Marrow of bone....1545-1547
Marsipobranchs....1548-1563
Meconium....1564-1572
Meninges....1573
Mesentery and omentum....1574-1579
Menstruation....1580-1582
Micropyle....1583-1587
Mouth....1588-1593
Muscles....1594-1652
Myotomes....1653-1664

Nails....1665-1671
Nerves....1672-1706
Nerves, Cephalic....1707-1737
Nervous tissue....1738-1772
Neurentic canal....1773-1783
Neuron....1784-1801
Nose....1802-1820
Notochord....1821-1855
Nutrition of embryo....1856-1859

Oesophagus....1860-1865
Ovary....1866-1918
Ovulation....1919-1930
Ovum....1931-2033

Pancreas....2034-2037
Pericardium....2038
Pharynx....2039
Pineal gland....2040-2064
Placenta....2065-2257
Pregnancy....2258-2265
Proamnion....2266-2267
Protoplasm....2268-2276

Reptiles....2277-2310

Salivary glands....2311-2312
Segmentation of body....2313-2318
Segmentation of ovum....2319-2357
Sex....2358-2381
Sexuality....2382-2403
Skeleton....2404-2473
Skull....2474-2539
Spermatogenesis....2540-2590
Spermatozoa....2591-2636
Spleen....2637-2643
Spinal cord....2644-2669
Stomach....2670-2679
Supra-renals....2680-2690
Sympathetic....2691-2694
Synovia....2695-2697

Tail....2698-2701
Teeth....2702-2755
Teleosts....2756-2820
Tendon....2821-2822
Teratology....2823-2824
Testis....2825-2836
Thymus and thyroid....2837-2859
Tongue and taste....2860-2865
Tonsil....2866-2869
Tubal pregnancy....2870-2871
Tunicates....2872-2873
Twins....2874-2880

Umbilical cord....2881-2894
Urogenital....2895-2967
Uterus....2968-3021

Veins....3022-3030
Vertebrates....3031-3039

Wolffian body....3040-3067

Yolk sac....3068-3082

ALLANTOIS.

1. Ahlfeld, F. Die allantois des menschen und ihr verhältniss zur nabelschnur. Arch. f. gynäk., x, 81–117, taf. iii. **76.2.**
2. Beddard, F. E. Note on the presence of an allantoic (anterior abdominal) vein in Echidna. Zool. anz., vii, 653–654. **84.1.**
3. Budge, A. Ueber die harnblase bei vogelembryonen. Deutsche med. woch., vii, 69–70. **81.1.**
4. Cadiat. L'allantoïde. Gaz. méd., Paris. sér. 4, vi, 97–98. **77.1.**
5. Coste, P. Vesicule allantoïde observée dans l'œuf der kanguroos. Compt. rend. acad. sc., v, 638–639. **37.1.**
6. Dastre, A. Recherches sur l'allantoide et le chorion de quelques mammifères. Ann. sc. nat., sér. 6, iii, 118 p., pls. vii-x. **76.1.**
7. Dobrynin, P. v. Ueber die erste anlage der allantois. Sitzb. Wien. akad., lxiv, 185-192, taf. i. **71.1.**
8. Hennig, C. Ueber die kapseln der allantois und über placenta. Sitzb. nat. ges. Leipzig, 1890, 28-37. **90.1.**
9. Krause, W. Ueber die allantois des menschen. Arch. f. anat. u. phys., 1875, 215; 1876, 204-207. **76.1.**
10. ———— Ueber die allantois des menschen. Zool. anz., iv, 185. **81.1.**
11. ———— Ueber die allantois des menschen. Z. Z., xxxvi, 175-179, taf. ix. **81.2.**
12. Kupffer, C. Die entstehung der allantois und die gastrula der wirbelthiere. Zool. anz., ii, 520-522; 593-597; 612-617. **79.1.**
13. Lieberkühn. Querschnitte von der anlage der allantois und der harnblase von meerschweinchen embryonen. Sitzb. Marburg. ges., 70-72. **82.2.**
14. Nagel, W. Ueber die entwickelung der harnblase beim menschen und bei säugethieren. Sitzb. preuss. akad. wiss. Berlin, xii, 177-181. **92.1.**
15. Olivetti, Marco. Ein beitrag zur kenntniss der ersten allantoisbildung. Wiener med. jahrb., 447-450, taf. xiii. **74.1.**
16. Preuschen, F. von. Die allantois des menschen; eine entwickelungsgeschichtliche studie auf grund eigener beobachtung. Wiesbaden, 195 p., taf. i-x. **87.1.**
17. Rauber, A. Die gastrula der wirbelthiere und die allantois. Zool. anz., iii, 180-185. **80.3.**
18. Strahl, H. Ueber die entwicklung der allantois der eidechse. Sitzb. Marburg. ges., 47-49. **80.2.**
19. ———— Ueber die entwicklung der allantois der eidechse. Sitzb. Marburg. ges., 25-26. **81.3.**
20. ———— Die allantois von Lacerta viridis. Sitzb. Marburg. ges., 25-27. **83.5.**

AMNION.

21. Ahlfeld, F. Zur genese der amnionzotten. (Antwort zur Winkler, F. N.) Arch. f. gynäk., vii, 567-570. **75.2.**
22. ———— Die verwachsungen des amnions mit der oberfläche der frucht. *In his:* Berichte arb. geb.-gyn. k. zu Marburg, Leipzig, iii, 158-165. **86.1.**
23. Ahlfeld, F. In wie weit ist das fruchtwasser ein nahrungsmittel für die frucht. Zeit. f. geburt. u. gynäk., xiv., H.2, 405-412. **88.2.**
24. Cane, Francis E. The functions of the amnion. Lancet. ii, 1274. **88.1.**

25. Döderlein. Bedeutung und herkunft des fruchtwassers. Centralbl. f. gynäk., xiii, II.31. 545-546. **89.1.**
26. Döderlein, Albert. Vergleichende untersuchungen über fruchtwasser und fötalen stoffwechsel. Arch. f. gynäk., xxxvii, 141-173. **90.1.**
27. Fleischmann, A. Mittelblatt und amnion der katze. Erlangen. 39 p. 8vo. **87.1.**
28. Guesserow, A. Zur lehre vom stoffwechsel des foetus. Arch. f. gynäk., iii, 241-270 **72.1.**
29. ——— Zur lehre vom Stoffaustausch zwischen mutter und frucht. Arch. f. gynäk., xiii, 56-72. **78.1.**
30. Haidlen, Richard. Ein beitrag zur lehre vom fruchtwasser. Arch. f. gynäk., xxv, 40-50. **85.1.**
31. Harnack, E. Ueber die zusammensetzung einer hydramnionflüssigkeit und den relativen salzgehalt in serösen flüssigkeiten Berliner klin. wochenschr., xxv, 821-822. **88.1.**
32. Hoffmann, C. K. Ueber das amnion des zweiblättrigen keimes. Arch. f. mikr. anat., xxiii, 530-536, taf. xxv. **84.1.**
33. Hotz, Anna. Das epithel des amnions. Inaug. diss., Bern. **78.1.**
34. Majewski, A. De substantiarum quae liquoribus amnii et allantoidis insunt rationibus diversis vitae embryonalis periodis. Dorpati Livonorum. 44 p., 3 tables. Inaug. diss. **58.1.**
35. Nagel, W. Beitrag zur lehre von der herkunft des fruchtwassers. Arch. f. gynäk., xxxv, 131-148, taf. i. **89.1.**
36. Opitz, W. Ueber die bedeutung des fruchtwassers für die ernahrung des kindes; blinde endigung der speiseröhre. Centralbl. f. gynäk., Leipzig, xi, 734-735. **87.1.**
37. Perenyi, Josef. Amnion und Wolff'scher gang der eidechsen. Math. u. naturw. berichte aus Ungarn, Berlin u. Budapest, vi, 14-26. **89.2.**
38. Ryder, J. A. The origin of the amnion. Am. nat., xx, 179-185. **86.3.**
39. Schenk, L. Beiträge zur lehre vom amnion. Arch. f. mikr. anat., vii, 192-201, taf. xviii. **71.1.**
40. Toerngren, A. Recherches expérimentales sur les voies qu'empruntent les substances contenues dans l'eau de l'amnios pour retourner dans la circulation maternelle. Soc. biol., v, no. 22, 543–544. **88.1.**
41. Viti, Arnaldo. L'amnios umano nella sua genesi e struttura ed in rapporto all' origine del liquido amniotico. Siena, 59 p., pl. i. **86.1.**
42. Vockeroth, C. Beitrag zur kenntniss von der entstehung des fruchtwassers. Greifswald, 23 p. 1 l. 8vo. (Diss.) **78.1.**
43. Wiener, M. Ueber die herkunft des fruchtwassers. Arch. f. gynäk., xvii, 24-44. **81.1.**
44. Winkler, F. N. Die zotten des menschlichen amnions. Jen. zeitschr. f. med. u. naturw., iv, 535-540. **68.1.**
45. ——— Textur, structur und zellleben in der adnexen des menschlichen eies. Jena (Hermann Dabis). 56 p., taf. i-ii. **70.1.**
46. ——— Erwiderung und berichtigung zu "Ueber die zotten des amnions" (Arch. f. gynäk., vi, 358). Arch. f. gynäk., vii, 325-330. **75.1.**
47. Winogradow. Ueber den bau des menschlichen amnions. Virchow's Arch., liv, 78-81, taf. iv, fig. 3-5. **72.1.**

AMNIOTIC FLUID.

48. Döderlein. Ueber herkunft und bedeutung des fruchtwassers. Verh. ges. f. gynäk., Leipzig, iii, 311-322. **90.2.**
49. Fehling, H. Physiologische bedeutung des fruchtwassers. Arch. f. gynäk., xiv, 221-244. **79.1.**
50. Hofmann, W. Ueber die herkunft des fruchtwassers. Würzburg, 221 p., 8vo. Inaug. diss. **88.1.**
51. Krukenburg, G. Kritische und experimentelle untersuchungen über die herkunft des fruchtwassers. Arch. f. gynäk., xxii, 1-46. **84.1.**
52. Levison, F. Fruchtwasser und hydramniose. Arch. f. gynäk., ix. 517-519. **76.1.**
53. Nahm, Georg. Ueber die herkunft und aufgabe des fruchtwassers. Würzburg, 27 p. 8vo. (Inaug. diss.) **88.1.**
54. Pinko, K. Das fruchtwasser und seine bedeutung für die frucht. Würzburg, 38 p. 8vo. (Inaug. diss.) **88.1.**
55. Prochownick, L. Beiträge zur lehre vom fruchtwasser und seine entstehung. Arch. f. gynäk., xi, 304-345. **77.1.**
56. Saudmeyer, W. Ueber den eiweissgehalt des fruchtwassers. Marburg, 27 p. 8vo. (Inaug. diss.) **88.1.**
57. Zycki, Anton. Das fruchtwasser, seine genese und seine bedeutung. Würzburg, 32 p. 8vo. (Inaug. diss.) **88.1.**

AMPHIBIA.

58. Baer, K. E. von. Die metamorphose des eies der batrachier vor der erscheinung des embryo und folgerungen aus ihr für die theorie der erzeugung. Müller's Arch., 481-509, taf. xi. **34.1.**
59. Bambeke, v. Recherches sur le développement du Pélobate brun (Pelobates fuscus Wagl.). Mém. cour. Belg. acad., xxxiv, 66 p., pls. i-v. **68.1.**
60. Clarke, S. F. The development of Amblystoma punctatum Baird. Studies lab. Johns Hopkins univ., i, 105-125, pl. i-iv. **80.1**
61. Gasser, E. Zur entwicklung von Alytes obstetricans. Sitzb. Marburg. ges., 1882, no. 5, 73-97. **82.3.**
62. Götte, A. Untersuchungen über die entwickelung des Bombinator igneus. Arch. f. mikr. anat., v., 90-125, taf. vi-vii. **69.3.**
63. ——— Die entwickelungsgeschichte der unke (Bombinator igneus). Leipzig, 964 p., taf. xxii. 8vo. **75.1.**
64. Houssay, F. Études d'embryologie sur l'axolotl. C. R. acad sc., Paris, cix, 703-706. **88.1.**

65. Houssay, F. Études d'embryologie sur les vertébrés. Arch. zool. expér., sér. 2, viii, 143-244, taf. x-xiv. **90.1.**
66. Houssay, F., *and* Battaillon. Formation de la gastrula du mésoblaste et de la chorde dorsale chez l'axolotl. C. R. acad. sc., Paris, cvii, 134-136. **88.1.**
67. ——— Segmentation de l'œuf et sort du blastopore chez l'axolotl. C. R. acad. sc., Paris, cvii, 282-284. **88.2.**
68. Johnson, Alice, *and* Sheldon, Alice. Notes on the development of the newt (Triton cristatus). Q. J. M. S., xxvi, 573-589, pls. xxiv-xxvi. **86.1.**
69. Kölliker. Note sur le développement des tissus des batraciens. Ann. sc. nat., sér. 3, vi, 91-108, pls. v-vii. **46.2.**
70. Lataste, F. Sur la position de la fente branchiale chez le têtard du Bombinator igneus. Act. soc. linn. Bord., xxxi., 95-97. **76.2.**
71. Moquin-Tandon, A. Développement des batraciens anoures. Ann. sc. nat., iii, 1-50, pls. i-ii. **76.1.**
72. Orr, Henry. Note on the development of amphibians, chiefly concerning the central nervous system; with additional observations on the hypophysis, mouth, and the appendages and skeleton of the head. Q. J. M. S., xxix, 295-324, pls. xxvii-xxix. **88.1.**
73. Sacchi, Maria. Contribuzioni all' istologia ed embriologia dell' apparecchio di gerente dei batraci e rettili. Milano, 50 p. tav. ii. (Att. Soc. ital. sc. nat., xxix.) **86.1.**
74. Schultze, O. Beitrag zur entwicklungsgeschichte der batrachier. Arch. f. mikr. anat., xxiii, 1-22, taf. i. **84.1.**
75. Scott, W. B., *and* Osborn, H. F. On some points in the early development of the common newt. Q. J. M. S., xix., 449-475, pls. xx-xxi. **79.1.**
76. Spencer, W. Baldwin. On the fate of the blastopore in Rana temporaria. Zool. anz., viii, 97-98. **85.2.**
77. ——— Some notes on the early development of the Rana temporaria. Q. J. M. S., xxv, 123-138, pl. x. **85.3.**
78. Stricker. Entwicklungsgeschichte von Bufo cinereus bis zum erscheinen der äusseren kiemen. Sitzb. Wien. akad., xxxix, 472-478. **60.1.**
79. Stricker, S. Untersuchungen über die ersten anlagen in batrachier-eiern. Z. Z., xi, 315-324, taf. xxvi. **61.1.**
80. ——— Untersuchungen über die entwicklung des kopfes der batrachier. Müller's Arch., 1864, 52-76, taf. i. **64.2.**
81. Török, A. v. Beiträge zur kenntniss der ersten anlagen der sinnesorgane und der primären schädelformation bei den batrachiern. Sitzb. Wien. akad., lii, 646-654, taf. i. **65.1.**
82. ——— Untersuchungen über die entwicklung der mundhöhle und ihrer nächsten umgebung im batrachierembryo. Sitzb. Wien. akad., liv, 75-80, taf. i. **66.1.**
83. Wiedersheim, R. Beiträge zur entwicklungsgeschichte von Proteus anguineus. Arch. f. mikr. anat., xxxv, 121-140, taf. vi-vii. **90.2.**
84. ——— Beiträge zur entwicklungsgeschichte von Salamandra atra. Arch. f. mikr. anat., xxxvi, 469-482, taf. xix. **90.4.**
85. Ziegler, F. Zur kenntniss der oberflächenbilder der Rana-embryonen. Anat. anz., vii, 211-215. **92.1.**

AMPHIOXUS.

86. Boveri, Th. Ueber die bildungsstäte der geschlechtsdrüsen und die entstehung der genitalkammern beim Amphioxus. Anat. anz., vii, 170-181. **92.1.**
87. Hatschek, B. Studien über entwicklung des Amphioxus. Arb. zool. inst. univ. Wien, iv, 1-88, taf. i-ix. **81.1.**
88. ——— Mittheilungen über Amphioxus. Zool. anz., vii, 517-520. **84.1.**
89. ——— Ueber den schichtenbau von Amphioxus. Anat. anz., iii, 662-667. **88.1.**
90. Köliker, Albrecht. Histologische studien an batrachierlarven. Z. Z., xliii, 1-40, taf. i-ii. **85.2.**
91. Kowalevsky. Entwicklungsgeschichte des Amphioxus lanceolatus. Mém. acad. St. Pét., sér. 7, xi, 17 p., taf. i-iii. **68.1.**
92. ——— Weitere studien über die entwicklungsgeschichte des Amphioxus lanceolatus, nebst einem beitrage zur homologie des nervensystems der würmer und wirbelthiere. Arch. f. mikr. anat., xiii, 181-204, taf. xv-xvi. **77.1.**
93. Willey, A. On the development of the atrial chamber of Amphioxus. Proc. roy. soc. Lond., xlviii, 68-89. **90.1.**
94. ——— The later larval development of Amphioxus. Q. J. M. S., xxxii. 183-234, pls. xiii-xv. **91.1.**

ANNELIDS.

95. Wilson, E. B. The embryology of the earthworm. Journ. morph., iii, 388-462, pls. xvii-xxii. **89.1.**
96. ——— The origin of the mesoblast bands in annelids. Journ. morph., iv, 205-219. **90.1.**

ANUS.

97. Fellner, L. Beitrag zur lehre von der entwicklung der kloake. Sitzb. Wien. akad., lxxi, 399-408, taf. i. **75.1.**
98. Gasser. Die entstehung der cloakanöffnung bei hühner-embryonen. Arch. f. anat. u. phys., anat. abth., 1880, 297-319, taf. xii-xiii. **80.1.**
99. List, Joseph Heinrich. Untersuchungen über das cloakenepithel der plagiostomen; theil i. Das cloakenepithel der rochen. Sitzb. Wien. akad., xcii, abth. 3, 270-305, taf. i-iv. **85.1.**
100. ——— Untersuchungen über das cloakenepithel der plagiostomen; theil ii. Das cloakenepithel der hale. Sitzb. Wien. akad., xcii, abth. 3, 412-438, taf. i-iv. **85.2.**

101. Retterer, E. Sur l'origine et l'évolution de la région anogénitale des mammifères. Journ. de l'anat., xxvi, no. 2, 126-151, pls. v-vi. **90.1.**
102. ——— Abstract. C. R. soc. biol. Paris, sér 9, ii, no. 5, 51-54. **90.2.**
103. Tourneux, F. Sur les premiers développements du cloaque, du tubercule génital et de l'anus chez l'embryon du mouton. Journ. de l'anat., xxiv, 503-518, pls. xiv-xvi. **88.1.**
104. ——— Preliminary note. C. R. soc. biol. Paris, sér 8, v. 633-636. **88.1.**
105. ——— Sur le mode de formation du périnée chez l'embryon du mouton par abaissement d'un repli périnéal unique. C. R. soc. biol. Paris, sér 9, ii, 75-77. **90.1.**
106. ——— Méchanisme suivant lequel s'opèrent la disjonction du rectum d'avec le bouchon cloacal, et la formation de l'anus chez l'embryon du mouton. C. R. soc. biol. Paris, sér 9, ii, 207-211. **90.3.**

AORTA.

107. Boas, J. E. V. Ueber die arterienbogen der wirbelthiere. Morph. jahrb., xiii, 115-118, taf. i. **87.1.**
108. Morpurgo, Benedetto. Ueber die entwickelung der arterienwand. Sitzb. Wien. akad., xc., abth. 3, 231-252, taf. i-ii. **85.1.**
109. Rathke, H. Ueber die entwicklung der arterien, welche bei den säugethieren von dem bogen der aorta ausgehen. Müller's Arch., 1843, 276-302, taf. xiii. **43.1.**
110. ——— Untersuchungen über die aortenwurzeln und die von ihnen ausgehenden arterien der saurier. Denkschr. Wien. akad., xiii, abth 2, 51-135, taf. i-vi. **57.1.**
111. Tonge, Morris. On the development of the semilunar valves of the aorta and pulmonary artery of the heart of the chick. Phil. trans., clix, 387-411, pls. xxxi-xxxii. **70.1.**
112. Türstig, John. Untersuchungen über die entwickelung der primitiven aorten. Schrift. naturf. ges. univ. Dorpat, i, 1-34, taf. i-iv. **84.1.**
113. ——— Mittheilung über die entwickelung der primitiven aorten nach untersuchungen an hühner-embryonen. Dorpat, 21 p. taf. i-ii. (Inaug. diss.) **86.1.**
114. ——— Mittheilungen über die entwicklung der primitiven aorten nach untersuchungen an hühnerembryonen. Dorpat, 19 p. 4 taf. **87.1.**
115. Vialleton, L. Développement des aortes postérieures chez l'embryon de poulet. C. R. soc. biol. Paris, sér 9, iii, 426-428. **91.1.**
116. Zimmermann, W. Ueber einen zwischen aorten und pulmonalbogen gelegenen kiemenarterienbogen beim kaninchen. Anat. anz., iv, 720. **89.1.**
117. Zimmermann. Ueber die kiemenarterienbogen des menschen. Verh. des Xten intern. med. kongress. Berlin, ii, abth. i, anat., 145-147. **91.2.**

ARCHENTERON.

118. Goette, A. Beiträge zur entwicklungsgeschichte des darmkanals im hühnchen. Tübingen, vi, 82 p., taf. i-v, 8vo. **67.1.**
119. Graf, Spee. Fettbildungen im entoblasten von säugetieren in verschiedenen altersstufen. Verh. des Xten intern. med. kongress, Berlin, ii, abth. i, anat., 138-139. **91.1.**
120. Prenant, A. Annotations sur le développement du tube digestif chez les mammifères. Journ. anat. et phys., 197-233, pls. xii-xiv. **91.2.**
121. Wolff, C. F. Ueber die bildung des darmkanals im bebrüteten hühnchen. Halle, 1812, 263 p., pl. ii, 8vo. **12.1.**

ARTERIES.

122. Hochstetter, F. Ueber die ursprüngliche hauptschlagader der hinteren gliedmasse des menschen und der säugethiere, nebst bemerkungen über die entwicklung der endäste der aorta abdominalis. Morph. jahrb., xvi, 300-318, taf. xi. **90.2.**
123. ——— Ueber den ursprung der arteria subclavia der vögel. Morph. jahrb., xvi, 484-493. **90.3.**
124. Julin, Charles. Des origines de l'aorte et des carotides chez les poissons cyclostomes. Anat. anz., ii, 228-238. **87.2.**

ATAVISM.

125. Ahlfeld, F. Missbildung und rückschlag. Centralbl. f. gynäk., ii, 385-391. **78.3.**

BIOGENESIS.

126. Blanchard, R. L'origine de la vie et l'organisation de la matière. Rev. sc., 22 année, xxxv, 161-170. **85.1.**

BIRDS.

127. Braun, M. Aus der entwicklungsgeschichte der papageien, i. Verh. phys.-med. ges. Würzburg, n. f., xiv, 121-123. **80.1.**
128. ——— Aus der entwicklungsgeschichte der papageien, iii u. iv. Verh. phys.-med. ges. Würzburg, xv, 120-122, 173-175. **81.1.**
129. ——— Die entwicklung des wellenpapageis (Melopsittacus undulatus Sh.), theil i-ii. Arb. zool.-zoot. inst. Würzburg, v, 161-204; 205-341, taf. viii-xiv. **82.3.**
130. Dareste. Recherches sur la dualité primitive du cœur et sur la formation de l'aire vasculaire dans l'embryon de la poule. C. R. acad. sc. Paris, lxiii, 603-606, 4to. **86.1.**
131. Fasola, G. D'quelques anomalies de la ligne primitive dans le poulet. Contributions pour son interprétation philogénétique. Arch. ital. biol., xiii, 82-88. **90.1.**
132. Haswell, Wm. A. Observations on the early stages in the development of the emu (Dromaeus novae-hollandiae). Proc. Linn. soc. New South Wales, ser 2, ii, 576-600, pls. viii-xv. **87.1.**
133. His, Wilhelm. Untersuchungen über die erste anlage des wirbelthierleibes. Die erste entwickelung des hühnchens im ei. Leipzig, 237 p., taf. i-xii. 4to. **68.1.**
134. ——— Neue untersuchungen über die bildung des hühnerembryo, i. Arch. f. anat. u. phys., anat. abth., 1877, 112-187, taf. v, vi. **77.2.**
135 Kupffer, C., *and* Benecke, B. Photogramme zur ontogenie der vögel (6 bogen text u. 15 phtogr. taf. mit 1 apparatzeichen). Nova acta Leop.-Carol. akad., xli, 150-196, taf. i-xv. **80.1.**
136. Moleschott, J. Zur embryologie des hühnchens. Unters. z. naturh. mensch. d. thiere, Giesen, x, 1-47. **70.1.**
137. Rauber, A. Ueber die stellung des hühnchens im entwicklungsplan. Leipzig, 28 p, taf. i-ii. 4to. **76 1.**
138. Serres. Des corps glycogéniques dans la membrane ombilicale des oiseaux. C. R. acad. sc. Paris, xlviii, 86. **59.1.**

BIRTH.

139. Berry, Hart D. Note on the mechanism of the separation of the placenta during the third stage of labour. Edinb. med. journ., xxxiii, 12-14. **87.1.**
140. Chadwick, J. R. Peristalsis of the genital tract and a new theory to explain relaxation of the vaginal outlet during labor. Gynec. trans., x, 221-228. **85.1.**
141. Geyl, A. Ueber die ursache des geburtseintritts. Arch. f. gynäk., xvii, 1-18. **81.1.**
142. Issmer, E. Zwei hauptmerkmale der reife neugeborner und deren physiologische schwankungen. Arch. f. gynäk., xxx, 277-315. **87.1.**
143. Jourdain, S. Sur la parturition der marsouin commun (Phocaena communis). C. R. acad. sc. Paris, xc, 138-139. **80.1.**

BLADDER.

143a. Debierre, Ch Développement de la vessie de la prostate et du canal de l'urèthre. Paris, Doin. 104 p. 4to. (Thèse.) **83.1.**
143b. Kelbel, Franz. Zur entwickelungsgeschichte der harnblase. Anat. anz., vi, 186-192. **91.1.**
143c. London, B. Das blasenepithel bei verschiedenen füllungszuständen der blase. Arch. f. anat. u. phys., phys. abth., 317-330. **81.1.**
143d. Suchannek, H. Beiträge zur kenntniss des urachus. Königsberg in Pr., 29 p. 1 l. 8vo. (Diss.) **79.1.**
143e. Takahasi, S. Beiträge zur kenntniss der lage der fötalen und kindlichen harnblase. Arch. f. anat. u. phys., anat. abth., 35-50, taf. iv. **88.1.**

BLASTOPORE.

144. Cholodkovsky, N. Ueber einige formen des blastopors bei meroblastischen eiern. Zool. anz., xiv, 159-160. **91.1.**
145. Erlanger, R. von. Ueber den blastoporus der anuren amphibien, sein schicksal und seine beziehungen zum bleibenden after. Zool. jahrb., iv, 239-256, taf. xv-xvi. **90.1.**
146. ——— Blastoporus-frage bei den anuren amphibien. Anat. anz., vi, 684-686. **91.1.**
147. Johnson, Alice. On the changes and ultimate fate of the blastopore in the newt (Triton cristatus). Proc. roy. soc. Lond., xxxvii, 65-66. **84.1.**
148. ——— On the fate of the blastopore and the presence of a primitive streak in the newt (Triton cristatus). Q. J. M. S., xxiv, 659-672, pl. xliv. **84.2.**
149. Keibel, F. Van Beneden's blastoporus und die Rauber'sche deckschicht. Anat. anz., ii, 769-773. **87.1.**
150. Morgan, T. H. On the amphibian blastopore. Studies lab. Johns Hopkins univ., iv, no. 6, 355-377, pls. xl-xlii. **90.2.**
151. Ostroumoff, A. Ueber den blastoporus und den schwanzdarm bei eidechsen und selachiern. Zool. anz., xii., 364-367. **89.1.**

152. Rauber, A. Die lage der keimpforte. Zool. anz., ii, 499-503. **79.2.**
153. ——— Noch ein blastoporus. Zool. anz., vi, 143-147; 163-167. **83.2.**

BLOOD.

154. Afanasieff. Ueber die entwicklung der ersten blutbahnen im hühnerembryo. Sitzb. Wien. akad., liii, 560-569, taf. i. **66.1.**
155. Aly, W. Ueber die vermehrung der rothen blutkörperchen bei den amphibien. Halle. **84.1.**
156. Arnold, J. Weitere beobachtungen über die theilungsvorgänge an den knochenmarkzellen und weissen blutkörpern. Virchow's Arch., xcvii, 107-130, taf. iv. **84.1.**
157. Auerbach, L. Ueber die blutkörperchen der batrachier. Anat. anz., v, no. 20, 570-578. **90.1.**
158. Balfour, F. M. The development of the blood-vessels of the chick. Q. J. M. S., n. s., xiii, 280-290, pls. xiv-xv. **73.1.**
159. Bayerl, B. Die entstehung rother blutkörperchen im knorpel am ossificationsrande. Arch. f. mikr. anat., xxiii, 30-44, taf. iii. **84.1.**
160. Berchon, E., *and* Périer, L. Note sur les globules du sang chez le foetus. Bordeaux méd., iv, 123. **75.1.**
161. Bertolet, R. M. Distinction between mammalian and reptilian blood. Month. micr. journ., xii, 91-92. **74.1.**
162. Bizzozero, G. Sur les plaquettes du sang des mammifères. Arch. ital. biol., xvi, 375-392. **91.2.**
163. ——— Ueber die blutplättchen. Intern. beitr. z. wiss. medicin, Berlin, i, 457-477. **91.3.**
164. Bizzozero, J. Ueber die bildung der rothen blutkörperchen. Virchow's Arch., xcv, 26-45. Arch. ital. biol., iv, 329-345, 1 pl. **84.1.**
165. Bizzozero, J., *and* Torre, A. Ueber die entstehung der rothen blutkörperchen bei den verschiedenen wirbelthierklassen. Virchow's Arch., xcv, 1-25, taf. 1. Arch. ital. biol., iv, 309-329. **84.1.**
166. Böttcher, A. Neue untersuchungen über die rothen blutkörperchen. Mém. acad. sc. St. Pét., sér 7, xxii, no. 11, 24 p., taf. i-ii. **76.1.**
167. Bütschli, O. Ueber eine hypothese bezüglich der phylogenetischen herleitung des blutgefässapparates eines theils der metazoen. Morph. jahrb., viii, 474-482. **83.3.**
168. Corning, H. K. Zur frage der blutbildung aus dem entoderm. Arch. f. mikr. anat., xxxvi. 516-527, taf. xxiv. **90.1.**
169. Cuenot, L. Sur le développement des globules rouges du sang. C. R. acad. sc. Paris, cvi, 673-675. **88.1.**
170. Davidoff, M. Ueber die entstehung der rothen blutkörperchen und den parablast von Salamandra maculosa. Zool. anz., vii, 453-456. **84.1.**
171. Denys, J. La structure de la moelle des os et la génèse du sang chez les oiseaux. La cellule, iv, 199-240, pls. i-ii. **87.1.**
172. Disse. Die entstehung des blutes und der ersten gefässe im hühnerei. Arch. f. mikr. anat., xvi, 545-592, taf. xxvi-xxviii. **79.1.**
173. Disse, J. Berichtigung. Arch. f. mikr. anat., xvii, 383-384. **80.1.**
174. Doléris, A., *and* Quindquand. Recherches sur le sang foetal, le sang du cordon ombilical, le sang placentaire; parallèle entre le sang de la mère et celui du foetus. Nouv. arch. obstétr. et gynécol., Paris, iii, 531-546. **88.1.**
175. Eberth, C. J. Ueber die blutplättchen der wirbelthiere. Fortschr. d. med., v, no. 8, 225-227. **87.1.**
176. Eberth, C. J., *and* Aly, W. Ueber die vermehrung der rothen blutkörperchen. Fortschr. d. med., iii, no. 1, 1-7, taf. 1. **85.1.**
177. Erb, W. Zur entwickelungsgeschichte der rothen blutkörperchen. Virchow's Arch., xxxiv, 138-193, taf. iv. **65.1.**
178. Foà, P. Beitrag zum studium der structur der rothen blutkörperchen der säugethiere. Beitr. pathol. anat. u. z. allg. pathol., Jena, v, no. 2, 253-263, 1 pl. **89.1.**
179. ——— Nouvelles recherches sur la production des éléments colorés du sang. Arch. ital. biol., xvii, 1-13. **92.1.**
180. Foà, P., *and* Salvioli, G. Sull' origine dei globuli rossi del sangue. Arch. sc. med. Torino e Roma, iv, 1-48, pl. i. **81.1.**
181. Flemming, W. Ueber theilung und kernformen bei leukocyten und über deren attractionssphären. Arch. f. mikr. anat.. xxxvii, 249-298, taf. xiii-xiv. **91.2.**
182. Funcke, E. Ueber die theilung der rothen blutkörperchen bei hühnerembryonen. Centralbl. f. d. med. wiss., no. 41, 754-756. **80.1.**
183. Gage, S. H. The form and size of the red blood corpuscles of the adult larval lamprey eels of Cayuga lake. Microscope, viii, 321-327. **88.1.**
184. Gensch, H. Die blutbildung auf dem dottersack bei knochenfischen (vorl. mittheilung aus dem anatomischen laboratorium zu Königsberg). Arch. f. mikr. anat., xix, 144-146. **81.1.**
185. Gibson, J. L. The blood forming organs and blood formation: an experimental research. Journ. anat. phys., xx, 100-113. **85.1.**
186. Götte, A. Beiträge zur entwicklungsgeschichte der wirbelthiere; ii. Die bildung der keimblätter und des blutes im hühnerei. Arch. f. mikr. anat., x, 145-199, taf. x-xii. **74.1.**
187. Grüber, A. Die gesamtzahl der blutkörperchen und ihre variation. Arch. f. anat. u. phys., phys. abth., 83-93. **89.1.**
188. Omitted.

189. Hausemann, D. Ein beitrag zur entstehung und vermehrung der leukocyten. Verh. anat. ges., v, 255-258. **91.1**.
190. Hart, Mrs. Ernest. Dr. Norris's third corpuscle of the blood; a criticism and refutation. Lond. med. rec., 1882. Oct. 15, pp. **82.1**.
191. Hayem, Georges. Du sang et de ses altérations anatomiques. Paris, xxvi, 1035 p., 126 fig. 8vo. **89.1**.
192. Howell, W. H. The origin and regeneration of blood corpuscles. N. Y. med. rec., xxxiv, 12, 337-338. **88.1**.
193. ——— The life history of the formed elements of the blood especially the red blood corpuscles. Journ. morph., iv, 57-116, pl. v. **90.1**.
194. Jones, T. W. The blood corpuscle considered in its different phases of development in the animal series; memoirs i, ii, iii. Phil. trans. roy. soc. Lond., 63-106, pls. i, ii. **46.1**.
195. Kölliker. Ueber die blutkörperchen eines menschlichen embryo und die entwicklung der blutkörperchen bei säugethieren. Z. rat. med., iv, 112-159, taf. i. **46.1**.
196. Krüger, F. Ueber das verhalten des fötalen bluts im momente der geburt. Virchow's Arch., cvi, 1-21. **86.1**.
197. Kuborn, P. Du développement des vaisseaux et du sang dans le foie de l'embryon. Anat. anz., v, no. 10, 277-282. **90.1**.
198. Kükenthal, W. Ueber die lymphoiden zellen der anneliden. Jen. zeitschr. f. med. u. naturw., n. f. xi, 319-364, taf. x-xi. **85.1**.
199. Lebouco, H. Sur le développement des capillaires et des globules sanguins chez l'embryon (communication préalable). Bull. soc. méd. de Gand, xlii, 100-102. **75.1**.
200. ——— Recherches sur le développement des vaisseaux et des globules sanguins dans les tissus normaux et pathologiques. Leipzig, vii, 128 p., pls. ii, 8vo. **76.2**.
201. Legge, Fr. Sulle cellule giganti e sulla genesi dei corpuscoli rossi del sangue nel fegato del Mus musculus. Bull. accad. med., Roma, xvi, 453-462. **90.1**.
202. Lilienfeld, Leon. Haematologische untersuchungen; erste mittheilung. Arch. anat. u. phys., phys. abth., 115-154, taf. v-vi. **92.1**.
203. List, J. H. Zur morphologie wandernder leukocyten. Arch. f. mikr. anat., xxviii, 251-256. **85.3**.
204. Löwit, M. Die umwandlung der erythroblasten in rothe blutkörperchen. Sitzb. Wien. akad., xcv, abth. 3, 129-178, 1 pl. **87.1**.
205. ——— Die anordnung und neubildung von leukoblasten und erythroblasten in den blutzellen bildenden organen. Arch. f. mikr. anat., xxxviii, 524-612, taf. xxxii-xxxiv. **91.2**. Preliminary notice. Anat. anz., vi, 344-348. **91.1**.
206. Macallum, A. B. Studies on the blood of Amphibia. No. iii. Trans. Can. inst., ii, pt. 2, 46-80, pl. i. **92.1**.
207. Malassez, L. Sur l'origine et la formation des globules rouges dans la moelle des os. Arch. de phys. norm. et path., sér 2, ix, no. 1, 1-47, pl. i. **82.1**.
208. Meissels, A. W. Studien über das zooid und oekoid bei verschiedenen wirbelthier-abtheilungen. Sitzb. Wien. akad., lxxxiv, abth. 3, 208-215, taf. i. **81.1**.
209. Minot, Charles Sedgwick. Zur morphologie der blutkörperchen. Anat. anz., v, 601-604., *Transl.* Amer. nat. xxiv, 1020-1023. **90.122**.
210. Mondino, C. La produzione delle piastrine e l'evoluzione delle emazie nel sangue dei vertebrati vivipari. Arch. ital. biol., xii (1889), 297-304. Rend. accad. d. linc., iv, fasc. 7, 378-382. **88.1**.
211. ——— Sulla genesi e sullo sviluppo degli elementi del sangue nei vertebrati. Palermo, 39 p. pl. ii, 4vo. **88.2**.
212. Mondino, C., *and* Sala, Luigi. Studi sul sangue. La produzione delle piastrine nel sangue dei vertebrati ovipari. Arch. ital. biol., xii. 297-304, pl. i. Rend. accad. d. linc., iv, fasc 7, 377. **83.1**.
213. Mosso, A. Die umwandlung der rothen blutkörperchen in leukocyten und die nekrobiose der rothen blutkörperchen bei der coagulation und eiterung. Arch. f. path. anat. u. phys. u. med., cix, 205-277. **87.1**.
214. ——— De la transformation des globules rouges en leucocytes et de leur necrobiose dans la coagulation et la suppuration. Arch. ital. biol., viii, 1-65. **87.2**.
215. ——— Le sang des poissons dans l'état embryonnaire et l'absence de leucocytes. Arch. ital. biol., x, 48-68. **88.2**.
216. Müller, Erik. Studien über den ursprung der gefässmuskulatur. Arch. anat. u. phys., anat. abth., 124-145, taf. viii-ix. **83.1**.
217. Müller, H. F. Zur frage der blutbildung. Sitzb. Wien. akad., xcvlii, abth. 3, 219-294, taf. i-v. **89.1**.
218. Neumann, E. Neue beiträge zur kenntniss der blutbildung. Arch. d. heilk., xv, 141-476, taf. vii. **74.1**.
219. Neumann, E. U. Ueber die entwicklung rother blutkörperchen in neugebildetem knochenmark. Virchow's Arch., cxix, 385-398. **90.1**.
220. Nicolaides, R. Ueber intracellulare genese von rothen blutkörperchen im mesenterium des meerschweinchens. Arch. f. anat. u. phys., phys. abth., 373-379, taf. xi. **91.1**.
221. Obrastzow. Zur morphologie der blutbildung im knochenmark der säugethiere. Virchow's Arch., lxxxiv, 358-414, taf. ix. **81.1**.
222. Peaslee, E. R. The physiology of the foetal circulation. Am. med. monthly, i, 321-346. **54.1**.
223. Permeschko. Ueber die theilung der rothen blutkörperchen bei amphibien. Centralbl. med. wiss., 673-675. **79.1**.
224. ——— Zur frage über die theilung der zellkernes. Biol. centralbl., i, 52-54. **81.1**.
225. Pouchet, G. The origin of the red blood corpuscles. Q. J. M. S., xx, 331-350. **80.1**.

226. Prévost *and* Lebert. Mémoire sur la formation des organes de la circulation et du sang dans les batraciens. Ann. sc. nat., sér. 3, i, 193-229, pl. ix-x. **44.1**.
227. ——— Mémoire sur la formation des organes de la circulatiou du sang dans l'embryon du poulet. Ann. sc. nat., sér. 3, i, 265-312, pls. xi-xv. **44.2**.
228. ——— Mémoire sur la formation des organes de la circulation et du sang dans l'embryon du poulet. Ann. sc. nat., sér. 3, ii, 222-247. **44.3**.
229. ——— Abstract. Ann. sc. nat., iii, 96-99. pl. i. **44.5**.
230. Ranvier, L. Recherches sur les éléments du sang. Arch. phys., sér. 2, ii, 1-15, pl. i. **75,2**.
231. Remak, R. Ueber die theilung der blutzellen beim embryo. Müller's Arch., 178-188, taf. viii. **58.1**.
232. Rindfleisch, E. Experimental studien über die histologie des blutes. Leipzig, 46 p. 1 pl. 8vo. **63.1**.
233. ——— Ueber knochenmark und blutbildung. Arch. f. mikr. anat., xvii, 1-11, 21-24, taf. i. **80.1**.
234. Robin, Charles. Sur quelques points de l'anatomie et de la physiologie muqueuse et de l'épithélium utérine pendant la grossesse; des globules rouges du sang. Journ. de la phys., i, 46-71, 283-297. **58.1**.
235. Romiti, G. Studi di embriogenia; iii. Sullo sviluppo del sangue. Rivista clin. Bologna, ser. 2, iv, 337-338. **74.1**.
236. Sanfelice, F. Genèse des corpuscles rouges dans la moelle des os des vertébrés. Arch. ital. biol., xiii, 45-54. **90.1**.
237. Schäfer, E. A. Note on the intracellular development of blood corpuscles in Mammalia. Proc. roy. soc., xxii, 243-245. **74.1**.
238. Scherenziss, D. Untersuchungen über das fötale blut im momente der geburt. Dorpat, 36 p. 8vo. (Inaug. diss.) **88.1**.
239. Schmidt, H. D. On the origin and development of the coloured blood corpuscles in man. Monthly micr. journ., xi, 45-68, pls. xlix-l, and lower part of li. **74.1**.
240. Schwink. Untersuchungen über die entwickeluug des endothels und der blutkörperchen der amphibien. Morph. jahrb., xvii, 288-333, taf. xvii-xix. **91 1**.
241. Strahl, H. Die aulage des gefäss-systems in der keimscheibe von Lacerta agilis. Sitzb. Marburg. ges., 60-71. **83.6**.
242. ——— Bemerkungen über den kreislauf bei embryonen von Lacerta agilis und vivipara. Sitzb. ges. beförd. nat. Marburg, 113-120. **84.6**.
243. Stricht, O. van der. Le développement du sang dans le foie embryonnaire. Arch. de biol., xi, 19-113, pl. i-ii. **91.1**.
244 ——— Division mitosique des érythroblastes et des leucoblastes à l'intérieur du foie embryonnaire des mammifères. Anat. anz., vi, 591-594. **91.2**.
245. Thomson, Allen. On the development of the vascular system in the foetus of vertebrated animals. Edinb. new phil. journ., 295-327, pl. ii-iii. **30.1**.
246. ——— On the development of the vascular system in the foetus of vertebrated animals. Part ii. Edinb. new phil. journ., 88-111, pls. ii-iii, 251-283. **1.1**.
247. Tietze, Alex. Untersuchungen über das blut des fötus. Breslau, 45 p. 8vo. (Inaug. diss.) **87.1**.
248. Uskow, N. Die blutgefässkeime und deren entwicklung bei einem hühnerembryo. Mém. acad. sc. St. Pét., sér. 7, xxxv, no. 4, 48 p. taf. i-ii. **87.1**.
249. Wenckebach, K. F. Development of the blood corpuscles in the embryo of Perca fluviatilis. Journ. of anat. phys., xix, 231-236. **85.1**.
250. White, M. C. Morphology of embryogenic blood. Proc. Conn. med. soc., Bridgeport, iv, 185-187. **90.1**.
251. Wissozky, N. Ueber das eosin als reagens auf hämoglobin und die bildung von blutgefässen und blutkörper hühnerembryonen. Arch. f. mikr. anat., xiii, 479-496, taf. xxxi. **77.1**.
252. Ziegenspeck, K. Ueber den blutkreislauf des säugethier- und menschenfötus. Preyer, Specielle phys. d. embryo, 596-607. **83.1**.
253. Ziegler, E. Die entstehung des blutes bei knochenfischembryonen. Arch. f. mikr. anat., xxx, 596-665, taf. xxxvi-xxxviii. **87.1**.
254 Ziegler, H. E. Die entstehung des blutes der wirbelthiere. Ber. nat. ges. Freiburg i. B., iv, H.5, 171-182. **89.1**.

BLOOD VESSELS.

255. Arnold, J. Experimentelle untersuchungen über die entwickelung der blutcapillaren. Arch. f. path. anat. u. phys. klin. med., liii, 70-92, taf. i-iii. **71.1**.
256. ——— Experimentelle untersuchungen über die entwickelung der blutcapillaren; ii. Die entwickelung der capillaren bei der keratitis vasculosa. Arch. path. anat. u. phys. klin. med., liv, 1-30, taf. i. **72.2**.
257. ——— Beiträge zur entwickelung der blutcapillaren; iii. Entwicklung der blutcapillaren im embryonalen glaskörper. Virchow's Arch., liv, 408-428, taf. xviii, fig. i-vi. **72.1**.
258. Ayers, H. The morphology of the carotids based on a study of the blood vessels of Chlamydoselachus anguineus Garman. Bull. mus. comp. zool., xvii, 191-223, 1 pl. **89.1**.
259. Bobritzky, C. Ueber entwickelung der capillargefässe. Centralbl. f. med. wiss., Berlin, xxiii, 769-771. **85.2**.
260. Callender, G. W. The formation of the subaxial arches in man. Phil. trans. London, clxi, 119-127, pl. i. **72 1**.

261. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; xiii. Ueber nerven und gefässe bei Ammocoetes und Petromyzon planeri. Mitth. zool. stat., Naples, viii, 233-306, taf. x-xv. **88.2.**
262. Golubew, Alex. Beiträge zur kenntniss der baues und der entwickelungsgeschichte der capillargefässe des frosches. Arch. f. mikr. anat., v, 49-89, taf. v. **69.1.**
263. Hochstetter, F. Ueber die bildung der hinteren hohlvene bei den säugethieren. Anat. anz., ii, 517-520. **87.2.**
264. ——— Beiträge zur entwickelungsgeschichte des venensystems der amnioten. Morph. jahrb., xiii, 575-585, taf. xxiv. **88.1.**
265. ——— Zur morphologie der vena cava inferior. Anat. anz., iii, 867-872. **88.3.**
266. ——— Ueber die entwickelung der A. vertebralis beim kaninchen, nebst bemerkungen über die entstehung der Ansa vieussenii. Morph. jahrb., xvi, 572-586, taf. xxi. **90.1.**
267. Lebouco, H. Recherches sur le développement des vaisseaux et des globules sanguins dans les tissus normaux et pathologiques. Leipzig, 28 p. taf. ii. **76.1.**
268. Makay, J. Yule. The development of the branchial arterial arches in birds with special reference to the origin of the subclavians and carotids. Phil. trans., London, clxxix, 111-139, pls. xxii-xxv. **88.1.**
269. Marshall, A. M., *and* Bles, Ed. J. The development of the blood vessels in the frog. Stud. biol. lab. Owen's coll., ii, 185-268, pls. xiii-xv. **90.2.**
270. Morpurgo, B. Ueber die entwicklung der arterienwand. Sitzb. Wien. akad., xc, abth. 3, 231-253, taf. i-ii. **84.1.**
271. Osler, W. Note on cells containing red blood corpuscles. Lancet, i, 181. **82.1.**
272. Platner, E. A. Einige beobachtungen über die bildung der capillargefässe. Müller's Arch., 525-526, taf. xvi. **44.1.**
273. Ranvier, L. Du développement et de l'accroissement des vaisseaux sanguins. Arch. de phys., vi, 429-445, pls. xviii-xix. **74.2.**
274. Retterer, *and* Robin, C. L. Sur la distribution des fibres élastiques dans les parois artérielles et veineuses. Journ. de l'anat. et phys., xx, 116-138. **84.1.**
275. Rouget, Ch. Mémoire sur le développement, la structure et les propriétés physiologiques des capillaires sanguins et lymphatiques. Arch. de phys., v, 603-663, pls. xxi-xxv. **73.1.**
276. ——— Note sur le développement de la tunique contractile des vaisseaux. C. R. acad. sc. Paris, lxxix, 559-562. **74.2.**
277. Strawniski, N. Ueber den bau der nabelgefässe und über ihren verschluss nach der geburt. Sitzb. Wien. akad., lxx, abth. 3, 85-100, taf. i-iii. **74.1.**
278. Schmidt, H. D. On the development of the smaller blood vessels in the human embryo. Monthly micr. journ., xiii, 1-18, pls. lxxxvii-xc. **75.1.**

BONE.

279. Aeby, C. L. Ueber die symphysis ossium des menschen nebst beiträgen zur lehre vom hyalinen knorpel und seiner verknöcherung. Zeitschr. f. rat. med., Reihe 3, iv, 1-77, taf. i-viii. **58.1.**
280. Brock, J. Ueber die entwicklung des unterkiefers der säugethiere. Z. Z., xxvii, 278-318, taf. xix-xx. **76.1.**
281. Czermak, N. Vergleichende studien über die entwicklung des knochen- und knorpelgewebes. Anat. anz., iii, 470-480. **88.1.**
282 Dixey, F. A. On the ossification of the terminal phalanges of the digits. Proc. roy. soc. London, xxxi, 63-71, pls. i-ii. **81.1.**
283. Drogoul. Sul processo normale di ossificazione. Atti accad. sc. Torino, xxiv, 264-269, pl. iv. **89.1.**
284. Gegenbaur, C. Ueber die bildung des knochengewebes. Jen. zeitschr. f. med. u. naturw., i, 343-369, taf. viii. **64.3.**
285. ——— Ueber die bildung des knochengewebes. Jen. zeitschr. f. med. u. naturw., iii, 206-246, taf. iii-iv. **67.3.**
286. Kaczander, J. Ueber den ossificationsprozess. Virchow's Arch., lxxxvii, 189-193, taf. vA, fig. 1-7. **82.1.**
287. Kölliker, A. Der feinere bau des knochengewebes. Z. Z., xliv, 644-680, taf. xxxvi-xxxix. **86.2.**
288. Landois, L. Untersuchungen über die bindesubstanz und den verknöcherungsprocess derselben. Zeitschr. f. wiss. zool., xvi, 1-26, taf. i. **66.2.**
289. Leser E. Ueber histologische vorgänge an der ossificationsgrenze mit besonderer berücksichtigung des verhaltens der knorpelzellen. Arch. f. mikr. anat., xxxii, 214-222. **88.1.**
290. Lieberkühn, N. Weitere beiträge zur lehre von der ossification. Arch. f. anat. phys., 614-634, taf. xvi. **63.1.**
291. ——— Ueber das wachsthum des stirnzapfens der geweihe. Arch. f. anat. phys., 404-407. **65.1.**
292. Lieberkühn, N., *and* Bermann, J. Ueber resorption der knochensubstanz. Abh. Senckentb. naturf. ges., xi, 57-124, i-viii. **79.1.**
293. Löwe, L. Ueber die umwandlung der osteoklasten im knochenmark, nebst bemerkungen über knochenwachsthum. Arch. f. mikr. anat., xvi, 618-626, taf. xxix, fig. 11-19. **79.5.**
294. Macewen, W. The osteogenic factors in the development and repair of bone. Ann. surg. St. Louis, vi. 289-306. **77.1.**
295. Menden, J. Beitrag zur casuistik der ossificationsdefecte am schädel der neugeborenen. Marburg, 10 p., pl. i. 4to. **75.1.**
296. Omitted.

297. Müller, H. Ueber die entwicklung der knochensubstanz, nebst bemerkungen über den bau rachitischer knochen. Z. Z., ix, 147-233, taf. ix-x. **59.1.**
298. Ranvier, L. Quelques faits relatifs au développement du tissu osseux. C. R. acad. sc. Paris, lxxvii, 1105-1109. **73.1.**
299. Retzius, G. Zur kenntniss der enchondralen verknöcherung. Biol. foren. forh. Stockholm, i, 5-8, taf. i. **89.2.**
300. Rouget, Ch. Développement et structure du système osseux. Paris, 72 p., 1 pl. 8vo. **56.1.**
301. Schäfer, E. A. Notes on the structure and development of osseous tissue. Q. J. M. S., xvii, 132-144, pls. vii-viii. **78.1.**
302. Schaffer, J. Die verknöcherung des unterkiefers und die metaplasiefrage; ein beitrag zur lehre von der osteogenese. Arch. f. mikr. anat., xxxii, 266-378, taf. ix-xii. **88.1.**
303. Schöney, L. On the ossification process in birds and the new formation of red blood-corpuscles during the ossification process. Month. micr. journ., xvi, 67-74, pls. cxlvi-cxlviii. **76.1.**
304. Schulin, Karl. Ueber die architektur des knochengewebes. Zeitschr. f. anat. entwick.-gesch., ii, 198-213, taf. viii. **77.1.**
305. Strelzoff, Z. Z. Ueber die histogenese der knochen. Unters. a. d. pathol. inst. Zürich, 1-94, taf. iv. **73.1.**
306. Stricht, O. van der. Recherches sur la structure de la substance fondamentale du tissu osseux. Arch. de biol., ix, 27-53, pl. i-ii. **89.1.**
307. Suddith, W. X. On some of the phases of embryonic bone development. Trans. internat. med. congress, ix, pt. 3, 151-159. **87.1.**
308. Waldeyer, W. Ueber den ossifikationsprocess. Arch. f. mikr. anat., i, 354-374, taf. xxiii. **65.2.**
309. Wolf, Julius. Ueber das wachstum des unterkiefers; zweiter beitrag zu den experimentellen untersuchungen über das knochenwachstum. Virchow's Arch., cxiv, 493-547, taf. xiii. **88.1.**

BRAIN.

309a. Bellonci, G., *and* Stefani, A. Contribution à l'histogenèse de l'écorce cérébellaire. Arch. ital. biol., xi, 21-25. **89.1.**
310. Below, E. Die ganglienzellen des gehirns bei verschiedenen neugeboreuen thieren (aufsatz ohne titel). Arch. f. anat. u. phys., phys. abth., 187-188. **88.1.**
311. Bischoff, Th. L. W. Die grosshirnwindungen des menschen mit berücksichtigung ihrer entwicklung bei dem foetus und ihrer anordnung bei den affen. Abh. Wien. akad., x, abth. 2, 391-497, taf. i-vii. **68.1.**
312. Blumenau, L. Zur entwicklungsgeschichte und feineren anatomie des hirnbalkens. Arch. f. mikr. anat., xxxvii, 1-15, taf. 1. **91.1.**
313. Branne, W. Das gewichtsverhältniss der rechten und linken hirnhälfte beim menschen. Arch. f. anat. u. phys., anat. abth., 253-270. **91.1.**
314. Callender, G. W. Lectures on the formation and early growth of the brain of man. Brit. med. journ., i, 731-733. **74.1.**
315. Cleland, J. On the development of the brain. Journ. anat. phys., x, 457-458. Rep. Brit. assoc. adv. sc., 1875. **76.1.**
316. Cunningham, D. J. The fissure of Rolando. Journ. anat. phys., xxv, 1-23, pl. i. **90.1.**
317. ——— The Sylvian fissure and the island of Reil in the primate brain. Journ. anat. phys., xxv, 286-291. **91.1.**
318. ——— The development of the gyri and sulci on the surface of the island of Reil of the human brain. (Abstract.) Journ. anat. phys., xxv, 338-348. **91.2.**
319. Dursy, E. Beiträge zur entwicklungsgeschichte des hirnanhanges. Centralbl. med. wiss., vi, 113-115. **68.1.**
320. ——— Zur entwicklungsgeschichte des kopfes des menschen und der höheren wirbelthiere. Tübingen, xii, 232 p. 8vo, atlas 4to, pls. i-ix. **69.1.**
321. Ecker, A. Zur entwicklungsgeschichte der furchen und windungen der grosshirn-hemisphären im foetus des menschen. Arch. f. anthrop., iii, 203-225, taf. i-iv. **68.1.**
322. ——— Gehirn eines foetus von Cebus apella. Arch. f. anthrop., v, 455, taf. vi, fig. 4. **72.1.**
323. ——— Die hirnwindungen des menschen nach eigenen untersuchungen, insbesondere über die entwickelung derselben beim foetus und mit rücksicht auf das bedürfniss der ärzte. Braunschweig, 58 p. 8vo. **88.1.**
324. Edinger, L. Vergleichend-entwickelungsgeschichtliche studien im bereiche der gehirnanatomie; i. Ueber die verbindung der sensiblen nerven mit dem zwischenhirn. Anat. anz., ii, 145-153. **87.1.**
325. ——— Vergleichend-entwicklungsgeschichtliche und anatomische studien im bereiche des centralnerven-systems; ii. Ueber die fortsetzung der hinteren rückenmarkswurzel zum gehirn. Anat. anz., iv, 121-128. **89.1.**
326. Flesch. Ueber die ursache der hirnwindungen. Corr. schw. ärzte, xviii, 50-51. **88.2.**
327. Fuchs, S. Zur histogenese der menschlichen grosshirnrinde. Sitzb. Wien. akad., lxxxviii, 157-184. **84.1.**
328. Fusari, R. Sull' origine delle fibre nervose nello strato molecolare delle circonvoluzioni cerebellari delle uomo. Atti accad. sc. Torino, xix, 47-51. **83.1.**
329. Gerlach, von. On the cerebral vesicle in the human embryo. Trans. internat. med. congress, ix, pt. 3, 138-140. **87.1.**
330. Goette, A. Ueber die entstehung und die homologien des hirnanhangs. Zool. anz., vi, 344-347. **83.2.**

331. Goronowitsch, N. Das gehirn und die cranialnerven von Acipenser ruthenus; ein beitrag zur morphologie des wirbeltierkopfes. Morph. jahrb., xiii, 427-514, taf. xvii-xx. **88.1.**
332. Hamilton. On the corpus callosum in the embryo. Brain, 145-163. **85.1.**
333. Hamy, E. T. Contribution à l'étude du développement des lobes cérébraux des primates. Arch. zool. expér., 429-436. **72.1.**
334. Hensen, Victor. Beitrag zur morphologie der körperform und des gehirns des menschlichen embryos. His's Arch., 1-8, taf. i. **77.1.**
335. His, Wilhelm. Zur geschichte des gehirns sowie der centralen und peripherischen nervenbahnen beim menschlichen embryo. Abh. math. u. phys. cl. sächs. ges. d. wiss., xiv, 341-392, 2 taf. **88.3.**
336. ——— Sur le développement de la moelle allongée. Arch. sc. phys. et nat., xx, No. 10, 356-358. **88.5.**
337. ——— Die formentwickelung des menschlichen vorderhirns vom ende des ersten bis zum beginn des dritten monats. Abh. math. u. phys. cl. sächs. ges. d. wiss., xv, 675-735, taf. i. **89.3.**
338. ——— Ueber die entwickelung des riechlappens und des riechganglions und über diejenige des verlängerten markes. Verh. anat. ges., Berlin, iii, 63-66. **89.4.**
339. ——— Die entwickelung des menschlichen rautenhirns vom ende des ersten bis zum beginn des dritten monats; i. Verlängertes mark. Abh. math. u. phys. cl. sächs. ges. d. wiss., xvii, 1-74, taf. i-iv. **90.2.**
340. Holt, E. W. L. Observations upon the development of the teleostean brain with especial reference to that of Clupea harengus. Zool. jahrb., iv, 478-500, pls. xxix-xxxi. **90.1.**
341. Kollmann, Jul. Die entwicklung der adergeflechte; ein beitrag zur entwicklungsgeschichte des gehirnes. Leipzig. viii, 40 p., pl. i. 8vo. **61.1.**
342. Leche, Wilhelm. Ueber einige entwicklungs-stadien der hypophysis cerebri. Verh. biol. ver. Stockholm, i, H 3, 53-57. **89.1.**
343. Leuret, F., *and* Gratiolet, L. P. Anatomie comparée du système nerveux considérée dans ses rapports avec l'intelligence. Paris, 2 v., xxxii, 592 p., xi, 692 p.; with atlas, 60 p., pls. i-xxxii. fol. **39.1.**
344. Marchand, F. Ueber die entwickelung des balkens im menschlichen gehirn. Arch. f. mikr. anat., xxxvii, 298-334, taf. xv-xvi. **91.1.**
345. Meckel, J. F. Versuch einer entwicklungsgeschichte der centraltheile des nervensystems in den säugethieren. Deutsches arch. f. phys. Halle u. Berlin, i, 334; 589. **15.2.**
346. Mihalkowics, Victor v. Entwicklungsgeschichte des gehirns; nach untersuchungen an höheren wirbelthieren und dem menschen. Leipzig, 195 p., taf i-vii, 4to. **77.1.**
347. Mingazzini, G. Ueber die furchen und windungen des gehirns der primaten und der menschlichen frucht. Molesch. Unters. z. naturlehre, xiv, 177-229, taf. i. **90.1.**
348. Nakagawa, Isaac. The origin of the cerebral cortex and the homologies of the optic lobe layers in the vertebrates. Journ. morph., iv, 1-10, pl. i. **90.1.**
349. Osborn, H. F. Preliminary observations upon the brain of Menopoma and Rana. Proc. acad. nat. sc. Philadelphia, 262-274, pl. vi. **84.1.**
350. ——— The origin of the corpus callosum; a contribution upon the cerebral commissures of the Vertebrata. Morph. jahrb., xii, 223-251, pls. xiii-xiv. **86.1.**
351. ——— Observations upon the presence of the corpus callosum in the brains of the amphibians and reptiles; note upon the cerebral commissures in the lower Vertebrata and a probable fornix rudiment in the brain of Tropidonotus. Zool. anz., ix, 200-205; 577-578. **86.2.**
352. ——— The origin of the corpus callosum; a contribution upon the cerebral commissures of the Vertebrata. Part ii. Morph. jahrb., xii, 530-543, taf. xxv. **87.1.**
353. ——— The relation of the dorsal commissures of the brain to the formation of the encephalic vesicles. Am. nat., xxi, 940-941. **87.3.**
354. Rabl-Rückhard. Zur deutung und entwickelung des gehirns der knochenfische. Arch. f. anat. u. phys., anat. abth., 111-138, taf. vi-vii. **82.1.**
355. Retzius, A. Ueber die bildung der hemisphären und des gewölbes des hirns. Zeitschr. f. ges. med. Hamburg, xxxii, 532-536. **46.1.**
356. Reubold, W. Zur entwicklungsgeschichte des menschlichen gehirns. Festschr. z. 3. säcularfeier d. med. fac. Würzb., Leipzig, i, 165-185, 2 pls. **82.1.**
357. Sala, L. Zur feineren anatomie des grossen seepferdefusses. Zeitschr. f. wiss. zool., lii, 18-45, taf. iii-v. **91.1.**
358. Schmidt, F. Beiträge zur entwicklungsgeschichte des gehirns. Z. Z., xi, 43-61, taf. vi. **62.1.**
359. Schwalbe, G. Beitrag zur entwicklungsgeschichte des zwischenhirns. Sitzb. ges. med. u. naturw. Jena, 2-7. **80.1.**
360. Selenka, E. Das stirnorgan der wirbeltiere. Biol. centralbl., x, 323-326. **90.1.**
361. Shaw, J. Die decke der hinter- und nachhirnblase. Schenk's Mitth. embryol. inst. univ. Wien, i, 137-143. **80.1.**
362. Sutton, J. B. On the evolution of the central nervous system of vertebrates. Brain, pt. xliii, 336-342. **88.2.**
363. Tiedemann, Fr. Anatomie und bildungsgeschichte des gehirns im foetus des menschen. Nürnberg. **16.1.**
364. Turner, Wm. The convolutions of the brain. Journ. anat. phys., xxv, 105-152. Verh. d. X. internat. med. kongress, Berlin, ii, abth. i, anat., 8-46. **90.2.**
365. Waldeyer, W. Sylvische furche und Reil'sche insel des genus Hylobates. Sitzb. preuss. akad. wiss. Berlin, xvi, 265-277, taf. ii. **91.1.**

366. Waters, H. Some additional points on the primitive segmentation of the vertebrate brain. Zool. anz., xiv, 141-144. **91.1.**
367. Wiedersheim, R. Bewegungserscheinungen im gehirn von Leptodora hyalina. Anat. anz., v, 673-679. **90.5.**
368. Wilder, B. G. Do the cerebellum and the oblongata represent two encephalic segments or only one? Proc. Am. assoc. adv. sc., xxxiii, 523-529. **84.2.**
369. ——— The collocation of a suture and fissure in the human foetus. Journ. neur. ment. dis., xiii, No. 8. **86.2.**

CARTILAGE.

370. Hasse, C. Ueber den ban und über die entwicklung des knorpels bei den elasmobranchiern. Zool. anz., ii, 325-329; 351-355; 371-374. **79.1.**
371. ——— Das natürliche system der elasmobranchier auf grundlage des banes und der entwickelung ihrer wirbelsäule. Jena, 94 p., 12 taf., 4to. **82.1.**
372. Kolster, R. Ueber die intercellularsubstanz des netzknorpels. Arch. f. mikr. anat., xxix, 533-538, taf. xxxiii. **87.1.**
373. Leboucq, H. Études sur l'ossification; i. Évolution du cartilage embryonnaire chez les mammifères. Bull. acad. roy. Belg., sér. 2, xliv, 457-459, 561-588, pl. i. **77 1.**
374. Rabl-Rückhard, H. Ueber den netzknorpel des ohres. Arch. f. anat. phys., 41-65, taf. iiia, figs. 1-3. **63.1.**
375. Renaut, J. Sur la formation cloisonnante (substance trabéculaire) du cartilage hyalin foetal. C. R. acad. sc. Paris, civ, 1452-1455. **87.2.**
376. Schleicher, W. Die knorpelzelltheilung. Arch. f. mikr. anat, xvi, 248-309, taf. xii-xiv. **79.1.**
377. Solger, B. Ueber pericelluläre und intercelluläre ablagerungen im hyalinknorpel. Arch. f. mikr. anat., xxxiv, 408-428, taf. xxv. **89 2.**
378. ——— Ueber knorpelwachstum. Verh. anat. ges. Berlin, iii, 67-71. **89.1.**
379. Spina. Untersuchungen über die bildung der knorpelgrundsubstanz. Sitzb. Wien. akad., lxxxi, abth. 3, 28-39, taf. i. **80.1.**
380. Spronk, C. H. H. Zur kenntniss der structur des hyalinknorpels. Anat. anz., ii, 259-269. **87.1.**
381. Stricht, O. van der. Recherches sur le cartilage hyalin. Arch. de biol., vii, 1-92, pls. i-iii. **87.1.**
382. ——— Recherches sur le cartilage articulaire des oiseaux. Arch. de biol., x, 1-41, pls. i-ii. **90.1.**
383. Wolters, M. Zur kenntniss der grundsubstanz und der saftbahnen des knorpels. Arch. f. mikr. anat., xxxvii, 492-512, taf. xxv. **91.2.**

CELLS.

384. Altmann, R. Die genese der zelle. Beitr. z. phys., Carl Ludwig z. s. 70 geburtstag gewidmet, 235-259. **87.1.**
385. Bambeke, C. van. État actuel de nos connaissances sur la structure du noyau cellulaire à l'état de repos. Ann. soc. méd. Gand, 1-84. **85.2.**
386. ——— Des déformations artificielles du noyau. Arch. de biol., vii, 349-387, pls. xi-xiii. **86.1.**
387. Brass, A. Chromatin, zellsubstanz und kern; zugleich eine vorläufige antwort auf O. Hertwig's beleuchtung und widerlegung meiner biologischen studien. Marburg, 42 p. **85.1.**
388. Carnoy, J. B. La cytodiérèse chez les arthropodes; étude comparée du noyau et du protoplasme à l'état quiescent et à l'état cinétique. La cellule, i, fasc. 2, 191-440, 4to. **85.1.**
389. Flemming, W. Beiträge zur kenntniss der zelle und ihrer lebenserscheinungen. Arch. f. mikr. anat., xvi, 302-436, taf. xv-xviii. **78.1.**
390. ——— Zellsubstanz, kern und zelltheilung. Leipzig, viii, 424 p., pls. i-viii, 8vo. **82.1.**
391. Frenzel, J. Der zellkern und die bakteriensporе. Biol. centralbl., xi, 757-763. **91.9.**
392. Frommann, C. Struktur, lebenserscheinungen und reaktionen thierischer und pflanzlicher zellen. Sitzb. ges. f. med. u. naturw. Jena, 10 Nov. **82.1.**
393. ——— Kernbildung und kernreaktionen. Sitzb. ges. f. med. u. naturw. Jena, 12 Jan. **83.2.**
394. ——— Beitrag zur zellenlehre. Anat. anz., i, 208-211. **86.1.**
395. ——— Bemerkungen zur zellenlehre. Jen. zeitschr. f. med. u. naturw., n. f. xiv, 141-162. **88 2.**
396. ——— Zelle. Eulenburg's Realencyclopädie d. ges. heilkunde, xxi, 459-501. **90.2.**
397. Gaule, J. Der ökus der zellen. Beitr. z. phys., Carl Ludwig z. s. 70 geburtstag gewidmet, 132-148. **87.1.**
398. ——— Ueber die beziehungen der structur der gifte zu den veränderungen der zellen. Centralbl. f. phys., 373-377. **88.1.**
399. Geddes, P. A re-statement of the cell theory with application to the morphology, classification and physiology of protists, plants and animals together with an hypothesis of cell structure and an hypothesis of contractility. Proc. roy. soc. Edinb., xii, 262-292, pl. iv. **84.1.**
400. Goodale, G. L. Some recent investigations relative to cell-contents. Salem, 16 p. 8vo. **89.1.**
401. Haberlandt, G. Ueber einkapselung des protoplasmas mit rücksicht auf die funktion des zellkernes. Sitzb. Wien. akad., xcviii, abth. 1, 190-199, 1 pl. **89.1.**
402. Henking, H. Ueber plasmatische strahlungen. Verh. deutsch. zool. ges., 29-36. **91.2.**

403. Hermann, F. Ueber regressive metamorphosen des zellkernes. Anat. anz., iii, 58-62. **88.1**.
404. Hofer, Bruno. Experimentelle untersuchungen über den einfluss des kerns auf das protoplasma. Jen. zeitschr. f. med. u. naturw., xxiv, 105-176, taf. iv-v. **89.1**.
405. Ide. Manille. Nouvelles observations sur les cellules épithéliales. La cellule, v, 319-365, taf. I. **90.1**.
406. Klebs, E. Die bildung des kern-chromatins. Fortschr. d. med., vi, 906-909. **88.1**.
407. Leydig, F. Altes und neues über zellen und gewebe. Zool. anz., xi, 309-315; 328-333. **88.1**.
408. Macallum. A. B. Contribution to the morphology and physiology of the cell. Biol. lab. univ. Toronto, 32 p. **91.1**.
409. Mangin, Louis. Sur la substance intercellulaire. C. R. acad. sc. Paris, cx, 295-297. **90.1**.
410. Montgomery, Edmund. Are we "cell-aggregates"? Hempstead, Tex., 8 p. **80.1**.
411. Platner, G. Beiträge zur kenntniss der zelle und ihrer theilungserscheinungen. Arch. f. mikr. anat., xxxiii, 125-152, taf. viii-ix. **89.2**.
412. ——— Beiträge zur kenntniss der zelle und ihrer theilung; iv. Die entstehung und bedeutung der nebenkerne im pankreas, ein beitrag zur lehre von der sekretion. Arch. f. mikr. anat., xxxiii, 180-192, taf. xii. **89.3**.
413. ——— Beiträge zur kenntniss der zelle und ihrer theilung; v. Samenbildung und zellteilung im hoden der schmetterlinge; vi. Die bildung der ersten richtungsspindel im ei von Aulastomum gulo. Arch. f. mikr. anat., xxxiii, 192-204, taf. xiii; 204-216, taf. xiv. **89.4**.
414. Prenant, A. Observations cytologiques sur les éléments séminaux des gastéropodes pulmones. La cellule, iv, 135, 177. **88.1**.
415. Rabl, C. Bemerkungen über den bau und die entwickelung der gewebe. Fortschr. d. med., viii, 81-86. **90.1**.
416. ——— Bemerkungen über den bau der zelle. Prag. med. wochenschr., xv, no. 6, 69. **90.2**.
417. ——— Ueber die prinzipien der histologie. Verh. anat. ges. Berlin, iii, 39-56. **89.3**.
418. Rauber, A. Neue grundlegungen zur kenntniss der zelle. Morph. jahrb., viii, 233-338, taf. xi-xiv. **83.3**.
419. Schultze, O. Ueber den einfluss des hungers auf die zellkerne. Sitzb. Würzburg. phys.-med. ges., xvii, 140-147. **88.2**.
420. Strasburger, E. Ueber zellbildung und zelltheilung. Jena, ix, 256 p., taf. i-vii. **75.1**.
421. Turner, Sir Wm. The cell theory, past and present. Journ. anat., xxiv, pt. ii, 253-287. **90.1**.
422. Verworn, Max. Die physiologische bedeutung des zellkerns. Arch. f. ges. phys. mensch. tiere, li, 1-118, taf. i-vi. **91.1**.
423. Whitman, C. O. The seat of formative and regenerative energy. Journ. morph., ii, 27-49. **88.1**.

CELL DIVISION.

424. Burger, Otto. Ueber attraktionssphären in den zellkörpern einer leibesflüssigkeit. Anat. anz., vi, 484-489. **91.1**.
425. ——— Was sind die attraktionssphären und ihre centralkörper. Anat. anz., vii, 222-231. **92.1**.
426. Chun, Carl. Ueber die bedeutung der direkten kernteilung. Sitzb. phys.-ökon. ges. Königsberg, xxxi. **90.1**.
427. Cunningham, J. T. Review of recent researches on karyokinesis and cell division. Q. J. M. S., xxii, 35-49, pl. vi. **82.1**.
428. Denys, J. La cytodiérèse des cellules géantes et des petites cellules incolorées de la moelle des os. La cellule, ii, 241-286, pls. i-ii. **86.1**.
429. Flemming, W. Amitotische kerntheilung im blasenepithel des salamanders. Arch. f. mikr. anat., xxxiv, 437-450, taf. xxvii. **89.1**.
430. ——— Attraktionssphären und centralkörper in gewebszellen und wanderzellen. Anat. anz., vi, 78-81. **91.1**.
431. ——— Neue beiträge zur kenntniss der zelle. Arch. f. mikr. anat., xxxvii, 685-751, taf. xxxviii-xl. **91.3**.
432. ——— Ueber zellteilung. Verh. anat. ges., v, 125-143. **91.4**.
433. ——— Zur nomenklatur der zellteilung. Anat. anz., vii, 26-32. **92.1**.
434. Fol, Hermann. Die "centrenquadrille" eine neue episode aus der befruchtungsgeschichte. Anat. anz., vi, 266-274. **91.1**.
435. Frenzel, Joh. Zur bedeutung der amitotischen (direkten) kernteilung. Biol. centralbl., xi, 558-565. **91.1**.
436. ——— Die nucleoläre kernhalbirung. Arch. f. mikr. anat., xxxix, 1-32, taf. i. **92.1**.
437. Geberg, A. Zur kenntniss des Flemming'schen zwischen-körperchens. Anat. anz., vi, 623-625. **91.1**.
438. Heidenhain, Martin. Ueber die centralkörperchen und attraktionssphären der zellen. Anat. anz., vi, 421-427. **91.1**.
439. Hennegny, L. F. Nouvelles recherches sur la division des cellules embryonnaires chez les vertébrés. C. R. acad. sc. Paris, cxi, 116-118. **90.1**.
440. ——— Nouvelles recherches sur la division cellulaire indirecte. Journ. de l'anat. et phys., xxvii, 397-423, pl. xix. **91.1**.
441. Hertwig, O. Ueber pathologische veränderung des kernteilungsprocesses in folge experimenteller eingriffe. Intern. beitr. z. wiss. med. Berlin, i, 195-212. **91.1**.
442. Johnson, H. P. Amitosis in the embryonal envelopes of the scorpion. Bull. mus. comp. zool., xxii, 127-161, pl. i-iii. **92.1**.
443. Kostanecki, K. v. Ueber centralspindel-körperchen bei karyokinetischer zellteilung. Anat. hefte, heft 2, 205-212. **92.1**.

444. Meves, Fr. Ueber amitotische kernteilung in den spermatogonien des salamanders und verhalten der attraktionssphäre bei derselben. Anat. anz., vi, 626-639. **91.1.**

445. Nussbaum, M. Ueber spontane und künstliche zelltheilung. Sitzb. Niederrh. ges. nat. u. heilk. Bonn med. sect., Dec. 15. **84.1.**

446. Platner, Gustav. Die karyokinese bei den lepidopteren als grundlage für eine theorie der zellteilung. Intern. monatsschr. anat. u. phys., iii, 341-398, pl. xvii, A, B. **86.2.**

447. ——— Ueber die entstehung des nebenkerns und seine beziehung zur kerntheilung. Arch. f. mikr. anat., xxvi, 343-369, taf. xiv. **86.3.**

448. Prenant, A. Observations cytologiques sur les éléments séminaux des reptiles. La cellule, iv, 181-197, pls. i, ii. **87.3.**

449. Rabl, C. Ueber zelltheilung, i. Morph. jahrb., x, 214-330, taf. vii-xiii. **84.1.**

450. ——— Ueber zelltheilung. Anat. anz., iv, 21-30. **89.1.**

451. Solger, Bernhard. Ueber pigmenteinschlüsse in der attraktionssphäre ruhender chromatophoren. Anat. anz., vi, 282-284. **91.1.**

452. ——— Zur kenntniss der zwischenkörper sich teilender zellen. Anat. anz., vi, 482-483. **91.2.**

453. Scheviakoff, Wladimir. Ueber die karyokinetische kerntheilung der Euglypha alveolata. Morph. jahrb., xiii, 193-258, taf. vi-vii. **87.1.**

454. Schultze, O. Ueber zelltheilung. Sitzb. phys.-med. ges. Würzburg. **90.1.**

455. Schwarz, Emil. Ueber embryonale zelltheilung. Med. jahrb., Wien, lxxxiv, 215-258, taf. i. **88.1.**

456. Tangl, Franz. Ueber das verhältniss zwischen zellkörper und kern während der mitotischen teilung. Math. u. naturw. berichte aus Ungarn, Berlin, u. Budapest, vi, 61-77, taf. i. **89.1.**

457. Uskoff, N. Zur bedeutung der karyokinese. Arch. f. mikr. anat., xxi, 291-295. **82.1.**

458. Verson, E. Zur beurteilung der amitotischen kernteilung. Biol. centralbl., xi, 556-558. **91.1.**

459. Waldeyer, W. Karyokinesis and its relation to the process of fertilization. Q. J. M. S., xxx, 159-214; 215-281, pl. xiv. (Translation of no. 1290.) **89.2.**

460. Ziegler, H. E. Die biologische bedeutung der amitotischen (direkten) kernteilung im tierreich. Biol. centralbl., xi, 372-389. **91.1.**

461. Ziegler, H. E., *and* Rath, O. vom. Die amitotische kernteilung bei den arthropoden. Biol. centralbl., xi, 744-757. **91.2.**

CEREBELLUM.

462. Bechterew, W. Ueber die bestandtheile des vorderen kleinhirnschenkels. Arch. f. anat. u. phys., anat. abth., 195-204, taf. xiii. **88.1.**

463. Cajal, S. Ramon y. A propos de certains éléments bipolaires du cervelet avec quelques détails nouveaux sur l'évolution des fibres cérébelleuses. Intern. monatsschr. f. anat. u. phys., vii, 447-468. **90.2.**

464. Kölliker, A. Zur feineren anatomie des centralen nervensystems; erster beitrag: Das kleinhirn. Zeitschr. f. wiss. zool., xlix, 663-689, taf. xxx-xxxiii. **90.1.**

465. Lahousse, E. Recherches sur l'ontogenèse du cervelet. Arch. de biol., viii, 43-110, pls. iv-xi. **88.1.**

CERVICAL SINUS.

466. His, W. Ueber den sinus praecervicalis und über die thymus-anlage; nachtrag zur vorstehenden abhandlung. Arch. f. anat. u. phys., anat. abth., 421-427; 428-433, taf. xxii. **86.3.**

467. Rabl, Karl. Zur bildungsgeschichte des halses. Prag. med. wochenschr., xi, no. 52. **86.1.**

COELOM.

468. Butler, G. W. On the subdivision of the body cavity in lizards, crocodiles, and birds. Proc. zool. soc. Lond., 452-474, pls. xli-xlix. **89.1.**

469. Freund, M. B. Grundzüge der homologie im baue der drei doppelhöhlen des wirbelthier-körpers. Breslau, 26 p. **64.1.**

470. Grosglik, S. Schizoecoel oder entercoel? Zool. anz., x, 116-118. **87.1.**

471. Hertwig, O. *and* R. Die coelomtheorie; versuch einer erklärung des mittleren keimblattes. Jen. zeitschr. f. naturw., xv, 1-150, taf. i-iii. **81.1.**

472. His, Wilhelm. Die häute und höhlen des körpers. Basel, 34 p. 4to. **65.1.**

473. Kollman, J. Ueber verbindungen zwischen coelom und nephridium. Festschrift d. 300 jähr. best. d. Jul. Max. univ. Würzburg, 1-57, taf. i-ii. **82.2.**

474. Mall, F. Development of the lesser peritoneal cavity in birds and mammals. Journ. morph., v, 165-179. **91.2.**

475. Solger, B. Studien zur entwicklungsgeschichte des coeloms und des coelomepithels der amphibien. Morph. jahrb., x, 494-528, taf. xxiv-xxv. **85.1.**

476. Zörner, E. Bau und entwickluugsgeschichte des peritoneum nebst beschreibung des bauchfelles einiger edentaten. (Literatur.) Zeitschr. f. ges. naturw., F. 3, vi, 105-185, taf. i. **81.1.**

CONJUGATION.

477. Bütschli, O. Studien über die ersten entwickelungsvorgänge der eizelle, die zelltheilung und conjugation der infusorien. Abh. Senckenb. naturf. ges., x, 213-452, taf. i-xv. **76.1.**
478. ——— Balbiani und die conjugation der infusorien. Zool. anz., vi, 10-14; 38-42. **83.1.**
479. Gruber, August. Sexuelle fortpflanzung und konjugation. Humbolt, viii, 3-6. **88.2.**
480. ——— Die konjugation der infusorien. Biol. centralbl., x, 136-150. **90.1.**
481. Wolters, Max. Die conjugation und sporenbildung bei gregarinen. Arch. f. mikr. anat., xxxvii, 99-138, taf. v-viii. **91.1.**

CONNECTIVE TISSUE.

482. Bambeke, Ch. van. De l'origine des tissus de substance conjonctive. Ann. soc. belg. micr. Bruxelles, 119-148. **86.3.**
483. ——— De l'origine des tissus de substance conjonctive. Ann. soc. belg. micr. Bruxelles, xii, 121-148, pl. iii. **89.1.**
484. Breslauer, W. Ueber die entwickelung des fibrillären bindegewebes. Arch. f. mikr. anat., v, 512-516. **69.1.**
485. Durham, H. E. On wandering cells in echinoderms, etc., more especially with regard to excretory functions. Q. J. M. S., xxxiii, 81-122, pl. i. **91.1.**
486. Flemming, W. Zur entwickelungsgeschichte der bindegewebsfibrillen. Intern. beitr. z. wiss. med. Berlin, i, 213-222. **91.6.**
487. Hertwig, O. Ueber die entwicklung und den bau des elastischen gewebes im netzknorpel. Schultze's Arch., ix, 80-100, taf. vii. **73.1**
488. Kuskow, N. Beiträge zur kenntniss der entwickelung des elastischen gewebes im ligamentum nuchae und im netzknorpel. (Aus dem anat. inst. Berlin.) Arch. f. mikr. anat., xxx, 32-38, taf. iv. **87.1.**
489. Laulanié. Observations sur l'origine des fibrilles dans les faisceaux du tissu conjonctif. C. R. acad. sc. Paris, xci, no. 3, 180-182. **80.1.**
490. Löwe, L. Zur kenntnis des bindegewebes. Arch. f. anat. u. phys., 43-56, taf. iii. **79.6.**
491. Lwoff, Basilius. Ueber die entwicklung der fibrillen des bindegewebes. Sitzb. Wien. akad., xcviii, abth. 3, 184-210, 2 pls. **89.1.**
492. Mall, F. Reticulated and yellow elastic tissues. Anat. anz., iii, 397-401. **88.3.**
493. ——— Das reticulirte gewebe und seine beziehungen zu den bindegewebsfibrillen. Abh. math. u. phys. classe sächs. ges. d. wiss., xvii, 5-44. **91.1.**
494. Ognew, J. Zur frage von der morphologischen bedeutung des fibrillären bindegewebes. Arch. f. anat. u. phys., anat. abth., 437-450, taf. xx. **85.1.**
495. Pansini, Sergio. Sulla genese delle fibre elastiche. Il progresso medico. **87.1.**
496. Raudnitz, R. W. Beitrag zur kenntniss der im bindegewebe vorkommenden zellen. Arch. f. mikr. anat., xxii, 228-232. **83.1.**
497. Rollett, A. Ueber die entwicklnng des fibrillären bindegewebes. Unters. inst. f. phys. u. histol. Graz, 257-265. **73.1.**
498. Salvioli, I. Contributo allo studio dell' accrescimento del tessuto connettivo. Arch. per le sc. med. Torino, xiii, 281-290, pl. i. **89.1.**
499. Stricker. Ueber die bindesubstanzen im allgemeinen und über die gewebsentwickelung im centralen nervensystem. Anz. ges. d. ärzte Wien, 41-46: 48-52. **79.1.**
500. Waldeyer, W. Ueber bindegewebszellen. Arch. f. mikr. anat., xi, 176-194, taf. ix. **74.1.**
501. Zimmermann, K. W. Ueber die teilung der pigmentzellen speziell der verästelten intraepithelialen. Arch. f. mikr. anat., xxxvi, 404-410, taf. xv. **90.1.**

DECIDUA.

502. Ahlfeld, F. Die beschaffenheit der decidua des eies ein zeichen der reife oder frühreife der frucht. Centralbl. f. gynec., ii, 217-220. **78.2.**
503. ——— Ueber befunde an der decidua vera und reflexa reifer eier. Arch. f. gynäk., xiii, 290-292. **78.4.**
504. Boldt, H. J. Beitrag zur kenntnis der normalen gebärmutterschleimhaut. Deutsch. med. wochenschr., xvi, H. 36, 803-804. **90.1.**
505. Coste, R. Sur la formation de la caduque dans l'oeuf humain. C. R. acad. sc. Paris, xv, 2 sem., 37-38; 59-63; 162-167; 224-225. **42.1.**
506. Duncan, Matthews. Notes on the history of the mucous membrane of the body of the uterus. Edinb. med. journ., iii, 688-697. **58.1.**
507. Engelmann, Geo. J. The mucous membrane of the uterus, with especial reference to the development and structure of the decidua. (This is a translation with some changes of Kendrat and Engelmann, No. 1.) Amer. journ. obstetrics, viii, 30-87, pl. i. **75.1.**

508. Ercolani, G. B. Delle glandule otricolari dell' utero e dell' organo glandulare di nuova formazione, etc. Mem. accad. sc. ist. Bologna, ser. 2, vii, 133-207, taf. i-x. **68.1**.
509. ——— The utricular glands of the uterus, etc., translated from the Italian under the direction of H. O. Marcy. x, 305 p. Atlas 21 p. 15 pls. 4to. **80.2**.
510. Friedländer, Carl. Physiologisch-anatomische untersuchungen über den uterus; i. Die innenfläche des uterus frisch nach der geburt und die neugestaltung der uterusschleimhaut während des wochenbetts. ii. Die uterinsinusthrombose an der placentarstelle. Leipzig, 57 p. taf. i-ii. **70.1**.
511. Gervais, H. P. Sur un utérus gravide de Pontoporia blainvillei. C. R. acad. sc. Paris, xcvii, 760-762. **83.1**.
512. Haussmann. Lehre von decidua menstrualis. Beitr. z. geb. u. gynäk. Berlin, i, 155-277. **72.1**.
513. Heintze. Ueber den feineren bau der decidua. Centralbl. f. med. wiss., xiii, 33-35. **75.1**.
514. Kahlweiss, F. Ueber die veränderung der uterusschleimhaut während der gravidität und deren neugestaltung im wochenbette. Königsberg, 31 p. 8vo. (Diss.) **77.1**.
515. Kupffer, C. Decidua und ei des menschen am ende des ersten monats der gravidität. München. med. wochenschr., xxxv, 515-516; Sitzb. ges. morph. phys. München, iv, 56-61. **88.1**.
516. Langhans. Die lösung der mütterlichen eihäute. Arch. f. gynäk., viii, 287-297, taf. ix. **76.1**.
517. Lee. Observations on the veins of the uterine decidua. London med. gaz., n. s., i, 334-336. **38.1**.
518. Leopold, Gerhard. Studien über die uterusschleimhaut während menstruation, schwangerschaft und wochenbett. Arch. f. gynäk., xi, 110-144. taf. i-iii; 443-500, taf. xii-xv; xii, 169-210, taf. iii-v. **77.1**.
519. Luzi, F. Sulla provenienza degli elementi cellulare costituenti la decidua della coniglia. Boll. accad. med. Roma, anno xvi, 6 p. Abstract: Monitore zool. ital., ii, 10. **90.1**.
520. Minot, C. S. On the fate of the human decidua reflexa. Anat. anz., v, no. 22, 639-643. **90.124**.
521. Möricke. Die uterusschleimhaut in den verschiedenen altersperioden und zur zeit der menstruation. Zeitschr. f. geburtsk. u. gynäk., vii, 84-137. **82.1**.
522. Oliver, James. Menstruation — its nerve origin — not a shedding of mucous membrane. Journ. anat. phys., xxi, 378-384; Med. record New York, xxxii, 69-71. **87.1**.
523. Overlach, Martin. Die pseudomenstruirende mucosa uteri nach akuter phosphorvergiftung. Arch. f. mikr. anat., xxv, 191-235, taf. x-xi. **85.1**.
524. Pflüger. Ueber die bedeutung und ursache der menstruation. 8vo. **65.1**.
525. Romiti, G. Sull' anatomia dell' utero gravido. Monitore zool. ital., i, 15-16. **90.1**.
526. ——— Sur l'anatomie de l'utérus en gestation. Arch. ital. biol., xv, 254-261. **91.2**.
527. Rouvier, Jules. Recherches sur la menstruation en Syrie. Ann. gynéc., xxvii, 178-201. **87.1**.
528. Sutton, J. Bland. On menstruation in monkeys. Brit. gynec. journ., vii, 285-292; Med. press and circular London, n. s., xliii, 259-261. **86.1**.
529. Wokka, W. Ueber die von Ruge beschriebene fötale vascularisation der Serotina. Bern, 16 p. 8vo. (Inaug. diss.) **88.1**.

DERMIS.

530. Ravogli, A. Untersuchungen über den bau, die entwickelung und vereiterung der cutis. Wien. med. jahrb., 49-59, taf. i-ii. **79.1**.

DIAPHRAGM.

531. Cadiat. Du développement de la portion céphalo-thoracique de l'embryon, de la formation du diaphragme, des plèvres, du péricarde, du pharynx, et de l'oesophage. Robin's Journ. anat. et phys., 630-674, pls. xlii-xlv. **78.1**.
532. ——— Note sur la formation embryonnaire du péricarde, du diaphragme et des plèvres. Gaz. méd. Paris, 48-49. **79.1**.
533. Lockwood, C. B. The early development of the pericardium, diaphragm and great veins. Phil. trans. London, clxxix, 365-384, pls. liii-lxi. **88.1**. Abstracts, Proc. roy. soc. Lond., xliii, 273-276; Brit. med. journ., 731-735. **88.3**.
534. Ravn, E. Vorläufige mitteilnug über die richtung der scheidewand zwischen brust- und bauchhöhle in säugetierembryonen. Biol. centralbl., vii, 425-427. **87.1**.
535. ——— Om dannelsen af skillevaeggen mellem bryst-og bughulen hos pattedyrfostre; en embryologisk studie. Kjöbenhavn, 72 p., taf. i-x. **88.1**.
536. ——— Ueber die bildung der scheidewand zwischen brust- und bauchhöhle in säugetier-embryonen. Arch. f. anat. u. phys., anat. abth., 123-154, taf. ix-x. **89.2**.
537. ——— Studien über die entwickelung des zwerchfells und der benachbarten organe bei den wirbeltieren. Arch. f. anat. u. phys., anat. abth., suppl., 270-280, taf. x. **89.3**.
538. ——— Untersuchungen über die entwickelung des diaphragmas und der benachbarten organe bei den wirbeltieren. Arch. f. anat. u. phys., anat. abth., 412-426, taf. xxvi. **89.4**.
539. Uskow, N. Ueber die entwicklung des zwerchfells, des pericardiums und des cöloms. Arch. f. mikr. anat., xxii, 143-219, taf. iii-vi. **83.1**.

540. Waldeyer, W. Ueber die beziehungen der hernia diaphragmatica congenita zur entwicklungsweise des zwerchfells. Deutsch. med. wochenschr., x, 211-212. **84.1.**

EAR.

541. Ayers, Howard. The ear of man: its past, its present, and its future. Lectures biol. lab., i, 188-230. **91.1.**
542. ——— Die membrana tectoria—was sie ist, und die membrana basilaris—was sie verrichtet. Anat. anz., vi, 219-220. **91.2.**
543. Baginsky, Benno. Zur entwickelung der gehörschnecke. Arch. f. mikr. anat., xxviii, 14-37, taf. v-vi. **86.1.**
544. Blake, C. J. Accumulations of epidermis in the external auditory canal. Boston med. surg. journ., cviii, 433-434. **83.1.**
545. Böttcher, A. Ueber entwickelung und bau des gehörlabyrinths nach untersuchungen an säugethieren; th. 1. Nova acta leop.-carol. acad., xxxv, abh. v, 1-203, taf. i-xii. **69.1.**
546. Fraser, Alex. On the development of the ossicula auditus in the higher Mammalia. Phil. trans., clxxiii, 901-925, pls. liv-lviii. Abstract, Proc. roy. soc., xxxiii, 446-447. **82.1.**
547. Gellé. Gallertmasse der foetalen paukenhöhle. Gazette méd., no. 21, 274. **79.1.**
548. Gradenigo, G. Die embryonale anlage des mittelohres; die morphologische bedeutung der gehörknöchelchen. Med. jahrb., n. f., ii, 61-119. **87.1.**
549. ——— Die formentwickelung der ohrmuschel mit rücksicht auf die morphologie und teratologie derselben. (Orig. mitt.) Centralbl. f. med. wiss. Berlin, xxvi, 82-86; 113-117. **88.1.**
550. Gradenigo. Die entwickelung der ohrmuschel beim menschen und bei den säugethieren. Zeitschr. f. ohrenk. Wiesbaden, xix, 283-284. **89.1.**
551. Günther, A. F. Beobachtungen über die entwickelung des gehörorgans bei menschen und höheren säugethieren. Leipzig, 63 p., 1 pl., 8vo. **42.1.**
552. Hensen, Victor. Zur morphologie der schnecke des menschen und der säugethiere. Z. Z., xiii, 481-512, taf. xxxii-xxxiv. **63.1.**
553. ——— Ueber entwicklung und bau des gehörlabyrinths nach untersuchung an säugethieren. Arch. f. ohrenheilk., vi, 1-32, taf. i. **73.1.**
554. Hoffmann, C. K. Ueber die beziehung der ersten kiementasche zu der anlage der tuba Eustachii und des cavum tympani. Arch. f. mikr. anat., xxiii, 525-530, taf. xxv. **84.2.**
555. Hunt, D. A comparative sketch of the early development of the ear and eye in the pig, together with a new account of the development of the meatus externus, drum and Eustachian tube. Amer. journ. med. sc., lxxiii, 58-62. (Trans. intern. otolog. congress, 1876.) **79.1.**
556. Huxley, T. H. On the representative of the malleus and incus of the Mammalia in the other Vertebrata. Proc. zool. soc., 391-407. **69.1.**
557. Kuhn. Beiträge zur anatomie des gehörorganes; abtheil. 2. Ueber das häutige labyrinth der amphibien. Arch. f. mikr. anat., xvii, 479-550, taf. xl-xlv. **80.1.**
558. ——— Beiträge zur anatomie des gehörorganes; abtheil. 3. Ueber das häutige labyrinth der reptilien. Arch. f. mikr. anat., xx, 271-361, taf. xvii-xxiii. **82.1.**
559. Krause, Rudolf. Entwicklungsgeschichte der häutigen bogengänge. Arch. f. mikr. anat., xxxv, 287-304, taf. xv. **90.1.**
560. Lavdowsky, M. Untersuchungen über den akustischen endapparat der säugethiere. Arch. f. mikr. anat., xiii, 497-557, taf. xxxii-xxxv. **77.1.**
561. Mall, F. Development of the Eustachian tube, middle ear, tympanic membrane and meatus of the chick. Stud. lab. Johns Hopkins Univ., iv, 185-192, pls. xviii-xix. **88.1.**
562. Moldenhauer. Die erste anlage des mittelohrs und des trommelfells. Centralbl. f. med. wiss., xiv, 706-708. **76.1.**
563. Moldenhauer, W. Die entwicklung des mittleren und des äussern ohres. Morph. jahrb., iii, 106-151, taf. vi-ix. **77.1.**
564. Noorden, C. v. Die entwickelung des labyrinthes der knochenfische. Arch. f. anat. u. phys., anat. abth., 235-264, taf. x. **83.1.**
565. Nuel, J. Recherches microscopiques sur l'anatomie du limaçon des mammifères. Mém. cour. sav. étrang. acad. Belg., xlii, 84, pl. i-iv. **79.1.**
566. Pritchard, Urban. The development of the organ of Corti. Journ. anat. phys., xiii, 99-103, pl. ix. **79.1.**
567. Rauber, A., *and* Moldenhauer, W. Ist die tuben-paukenhöhle product des vorderdarms oder der mundbucht. Arch. f. ohrenheilk. Leipzig, xiv, 36-52, 1 pl. **78.1.**
568. Retzius, G. Die gestalt des membranösen gehörorgans des menschen. Biol. untersuch., ii, 1-32, taf. i-ii. **82.1.**
569. Rüdinger, N. Zur anatomie und entwickelung des inneren ohres. Monatschr. f. ohrenk. Berlin, xxii, 1-13; 33-41; 57-68, 3 pls. **88.1.**
570. ——— Zur entwickelung der häutigen bogengänge des inneren ohres. Sitzb. bay. akad. wiss. München, xviii, 493-502, taf. vi. **88.2.**

571. Salensky, W. Beiträge zur entwickelungsgeschichte der knorpeligen gehörknöchelchen bei säugethieren. Morph. jahrb., vi, 415-431, taf. xx. **80.1**.
572. Schenk, S. L. Untersuchungen über die erste anlage des gehörorgans der batrachier. Sitzb. Wien. akad., 1, 347-350, taf. i. **64.1**.
573. Schwalbe, G. Das Darwin'sche spitzohr beim menschlichen embryo. Anat. anz., iv, 176-189. **89.1**.
574. ——— Ueber auricular-höcker bei reptilien; ein beitrag zur phylogenie des äusseren ohres. Anat. anz., vi, 43-53. **91.1**.
575. ——— Beiträge zur anthropologie des ohres. Intern. beitr. z. wiss. med., Berlin, 93-144, 1 pl. **91.2**.
576. Siebenmann, F. Ueber die injection der knochenkanäle des aquaeductus vestibuli et cochleae mit Wood'schen metall. Mitth. a. d. anat. inst. Vesal. Basel, 672-684, taf. ix. **89.1**.
577. Staderini, R. Intorno alle prime fasi di sviluppo dell' annulus stapedialis. Monitore zool. ital., ii, 147-160, tav. ii. **91.1**.
578. Tuttle, A. H. The relation of the external meatus, tympanum and Eustachian tube to the first visceral cleft. Proc. Am. acad., 1883-'84, 111-132, pls. i-ii. **84.1**.
579. Urbantschitsch. Ein beitrag zur entwicklungsgeschichte der paukenhöhle. Sitzb. Wien. akad., lxvii, abth. 3, 19-30, taf. i. **73.1**.
580. ——— Ueber die als fistula auris congenita bezeichnete bildungsanomalie. Monatschr. f. ohrenheilk., Berlin, xi, 85-89. **77.2**.
581. ——— Ueber die erste anlage des mittelohrs und des trommelfelles. Mitth. embryol. inst. univ. Wien, i, 1-20, taf. i-ii. **80.1**.
582. Villy, Fr. The development of the ear and accessory organs in the common frog. Q. J. M. S., xxx, 523-550, pls. xxxiv-xxxv. Stud. biol. lab. Owens. coll., ii, 159-184, pls. xi-xii. **90.1**.
583. Wendt, H. Ueber das verhalten der paukenhöhle beim foetus und beim neugeborenen. Arch. d. heilk., xiv, 97-124. **73.1**.

ELASMOBRANCHS.

584. Balfour, F. M. A preliminary account of the development of the elasmobranch fishes. Q. J. M. S., xiv, 323-364, pls. xiii-xv. **74.1**.
585. ——— The development of the elasmobranch fishes. From B to G. Journ. anat. phys., x, 672-688, pl. xxix. **76.1**.
586. ——— A monograph on the development of the elasmobranch fishes. London, 295 p., pl. i-xx. **78.3**.
587. His, W. Ueber die bildung der haifischenembryonen. Zeitschr. f. anat. u. entwick., ii, 108-124, taf. vii. **77.1**.
588. Hoffmann, C. K. Contributions à l'histoire du développement des plagiostomes. Arch. néerland., xvi, 97-115, pl. v. **81.1**.
589. Kastschenko, N. Zur entwicklungsgeschichte des selachierembryos. Anat. anz., iii, 445-467. **88.1**.
590. Leuckart, R. Ueber die allmählige bildung der körpergestalt bei den rochen. Z. Z., ii, 254-267, taf. xvi. **50.1**.
591. Leydig, F. Beiträge zur mikroskopischen anatomie und entwicklungsgeschichte der rochen und haie. Leipzig, 127 p., taf. i-iv. **52.1**.
592. Parker, T. J. Note on the foetal membranes of Mustelus antarcticus; with an analysis of the pseudamniotic fluid by A. Liversidge. Trans. proc. New Zealand inst., xxii, 331-333, pl. xix. **89.1**.
593. Perugia, A. Nota sullo sviluppo dell' Acanthias vulgaris. Boll. soc. adriat. sc. nat. Trieste, v, 8-17, taf. i-iii. **79.1**.
594. Schultz, A. Zur entwicklungsgeschichte des selachiereies. Arch. f. mikr. anat., xi, 569-582, taf. xxxiv. **76.1**.
595. ——— Beitrag zur entwicklungsgeschichte der knorpelfische. Arch. f. mikr. anat., xlii, 465-478, taf. xxx. **77.1**.
596. Swaen, A. Études sur le développement de la torpille (Torpedo ocellata). Arch. de biol., vii, 537-585, pls. xiv-xvi. **87.1**.
597. Wood-Mason, J. Further observations of the gestation of Indian rays; being natural history notes from H. M. Indian marine survey steamer Investigator; ser ii, no. 2. Proc. roy. soc. Lond., l, 202-209. **92.1**.
598. Ziegler, H. E., *and* Ziegler, Friedrich. Beiträge zur entwickelungsgeschichte von Torpedo. Arch. f. mikr. anat., xxxix, 56-102, taf. iii-iv, and 10 figs. **92.1**.

ELASTIC TISSUE.

599. Deutschmann, R. Ueber die entwickelung der elastischen fasern im netzknorpel. Arch. f. anat. u. phys., 732-750, 1 taf. **73.1**.
600. Ewald, A. Zur histologie und chemie der elastischen fasern und des bindegewebes. Zeitschr. f. biol., xxvi, 1-56, taf. i. **89.1**.
601. Gerlach, L. Ueber die anlage und die entwicklung des elastischen gewebes. Morph. jahrb., iv, suppl., 87-116, taf. vi-vii. **78.1**.

EPIDERMIS.

602. Aeby. Die herkunft des pigmentes im epithel. Centralbl. f. med. wiss., 273-275. **85.1.**
603. Blaschko, A. Beiträge zur anatomie der oberhaut. Arch. f. mikr. anat., xxx, 495-528, taf. xxvii-xxx. **87.1.**
604. ——— Ueber den verhornungsprozess. Deutsch. med. wochenschr., xv, 683. Arch. f. anat. u. phys., phys. abth., 539-540. **89.1.**
605. Bowen, J. T. The epitrichial layer of the human epidermis. Anat. anz., iv, 412-416; 441-450. **89.1.**
606. Buzzi, Fausto. Keratohyalin und eleidin, ii. Monatschr. f. prakt. dermat. Hamburg, viii, 149-163, 1 taf. **89.1.**
607. Dönhoff. Ueber den einfluss der jahreszeit auf die haut der säugethierembryonen. Arch. f. anat. u. phys., 46-47. **75.1.**
608. Franck, L. Vernix caseosa. Deutsch. zeitschr. thiermed. vergl. path. Leipzig, ii, 229. **76.2.**
609. Frommann, C. Ueber die struktur der epidermis und dereste Malpighi an den zehen von hühnchen, die eben aus dem ei geschlüpft, oder demselben in den letzten tagen der bebrütung entnommen worden sind. Sitzb. Jen. ges. med.-naturw., 25 juni. **80.2.**
610. ——— Ueber die epidermis des hühnchens in der letzten woche der bebrütung. Jen. zeitschr. f. naturw., xvii, 941-950. **84.1.**
611. Gardiner, E. G. Beiträge zur kenntniss des epitrichiums und der bildung des vogelschnabels. Arch. f. mikr. anat., xxiv, 289-338, taf. xvii-xviii. Leipzig, 50 p. taf. i-ii. (Inaug. diss.) **84.1.**
612. Gegenbaur, C. Zur morphologie des nagels. Morph. jahrb., x, 465-479. **85.1.**
613. Grefberg, W. Die haut und deren drüsen in ihrer entwicklung. Mitth. embryol. inst. univ. Wien, ii, 125-158, taf. xviii-xx. **83.1.**
614. Hesse, Fr. Zur kenntniss der hautdrüsen und ihrer muskeln. Zeitschr. anat. entw. ges., ii, 274-286, taf. xii. **77.1.**
615. Ide, Manille. La membrane des cellules du corps muqueux de Malpighi. La cellule, iv, 403-427, pl. i. **87.1.**
616. Jarisch. Ueber die anatomie und entwickelung des oberhautpigmentes beim frosche. Arch. f. dermat. u. syphilis, xxiii, 559-590, taf. x. **91.1.**
617. Jeffries, J. A. The epidermal system of birds. Proc. Bost. soc. nat. hist., xxii, 203-241, pls. iv-vi. **83.1.**
618. Karg. Studien über transplantierte haut; i. Entwickelung und bedeutung des hautpigments. Arch. f. anat. u. phys., anat. abth., 369-406, taf. xx-xxii. **88.1.**
619. Kerbert, Coenraad. Ueber die haut der reptilien und anderer wirbelthiere. Arch. f. mikr. anat., xiii, 205-262, taf. xviii-xx. **77.1.**
620. Kodis, Theodor. Epithel und wanderzelle in der haut des froschlarvenschwanzes; zur physiologie des epithels. Arch. f. anat. u. phys., phys. abth., suppl., 1-40, taf. i-iv. **89.1.**
621. Kölliker, A. Ueber die entstehung des pigmentes in den oberhautgebilden. Zeitschr. f. wiss. zool. Leipzig, xlv, 713-720, taf. xxxvii-xxxviii; Abstract: Sitzb. phys.-med. ges. Würzburg. **87.3.**
622. ——— Zur entwicklungsgeschichte der äusseren haut. Z. Z., ii, 67-96, taf. vi-viii. **50.1.**
623. Kollmann, Arthur. Der tastapparat der hand der menschlichen rassen und der affen in seiner entwicklung und gliederung. Hamburg and Leipzig, 77 p. taf. i-ii **83.1.**
624. List, Joseph H. Zur herkunft des pigmentes in der oberhaut. Anat. anz., iv, 596-599. **89.1.**
625. Mertsching. Histologische studien über keratohyalin und pigment. Virchow's Arch., cxvi, 484-516, taf. ix. **89.1.**
626. Meyerson, Siegfr. Zur pigmentfrage. Virchow's Arch., cxviii, 197-208. **89.1.**
627. Minot, C. S. Structure of the human skin. Am. nat., xx, 575-578. **86.83.**
628. Morrison, Robert B. Notes on the formation of pigment in the negro. Med. news Philadelphia, lv, 393-395. **89.1.**
629. Piersol, G. A. Development of pigment within the epidermis. Univ. med. mag. Penn., ii, 571-579, 1 pl. **90.2.**
630. Ranvier, L. De l'éléidine et de la répartition de cette substance dans la peau, la muqueuse buccale et la muqueuse œsophagienne des vertébrés. Arch. de phys., xvi, 125-141, pl. iii. **84.1.**
631. Reinke, Fr. Untersuchungen über die horngebilde der säugethierehaut. Arch. f. mikr. anat., xxx, 182-204, taf. xi. **87.1.**
632. Renaut, J. Sur l'évolution épidermique et l'évolution cornée des cellules du corps muqueux de Malpighi. C. R. acad. sc. Paris, civ, 244-248. **87.1.**
633. Rémy, Ch. Recherches histologiques sur l'anatomie normale de la peau de l'homme. Journ. de l'anat., xiv, 352-357, pls. xix-xxii. **78.1.**
634. Retterer, Ed. Sur le lieu et le mode de formation du pigment cutané chez les mammifères. C. R. soc. biol. Paris, sér. 8, iv, 150-153. **87.1.**
635. Ryder, J. A. The phylogeny of the sweat-glands. Proc. Am. phil. soc., xxvi, 534-540. **89.1.**
636. Unna, P. Beiträge zur histologie und entwickelungsgeschichte der menschlichen oberhaut und ihrer anhangsgebilde. Arch. f. mikr. anat., xii, 665-741, taf. xxxi-xxxii. **76.1.**
637. ——— Entwicklungsgeschichte und anatomie (der haut). Ziemssen's Handb., xiv, erste hälfte, 1-114. **83.1.**
638. Warren, J. C. Note on the anatomy and pathology of the skin. Bost. med. surg. journ. **77.1.**
639. Welcker. Ueber die haut von Bradypus. Halle. **64.1.**

640. Zander, R. Untersuchungen über den verhornungsprocess; ii. Der bau der menschlichen epidermis. Arch. f anat. u. phys., anat. abth., 51-96, taf. v. **88.1.**

EVOLUTION OF MAN.

641. Albrecht, P. Sur la place morphologique de l'homme dans la série des mammifères. Hambourg, 13 p., 2 fig. **86.1.**
642. Bateson, W. The ancestry of the Chordata. Q. J. M. S., xxv, 535-571. **85.2.**
643. Baur, G. On the phylogenetic arrangement of the Sauropsida. Journ. morph., i, 93-104. **87.1.**
644. Chaille, Stanford E. Evolution and human anatomy. N. Y. med. rec., xv, 169-174. **79.1.**
645. Cleland, J. Terminal forms of life. Journ. anat. and phys. xviii, 345-362. **84.1.**
646. Cope, E. D. The relation of man to the tertiary Mammalia. Penn monthly, 879-885. **75.1.**
647. ——— A review of the modern doctrine of evolution. Am. nat., xiv, 166-178; 261-272. **80.1.**
648. ——— The evolutionary significance of human character. Am. nat., xvii, 907-919. **83.1.**
649. ——— The evidence for evolution in the history of the extinct Mammalia. Proc. Am. assoc. adv. sc., xxxii. **83.2.**
650. ——— The relations between theromorphous reptiles and the monotreme Mammalia. Proc. Am. assoc. adv. sc., xxxiii, 471-482. **85.2.**
651. Dall, W. H. On dynamic influences in evolution. Proc. biol. soc. Wash. **90.2.**
652. Dana, J. D. Classification of animals based on the principle of cephalization. Amer. journ. sc., ser. 2, xxxvi, 321-352. **63 1.**
653. Dohrn, A. Der ursprung der wirbelthiere und das princip des functionswechsels; genealogische skizzen. Leipzig, 87 p. **75.2.**
654. ——— Studien zur urgeschichte des wirbelthierkörpers. Mitth. zool. stat. Neapel, iii, 252-279, taf. xv-xix. **82.1.**
655. ——— Studien zur urgeschichte des wirbelthierkörpers; iii. Die entstehung und bedeutung der hypophysis bei Petromyzon planeri. Mitth. zool. stat. Neapel, iv, 172-189, taf. xviii. **83.1.**
656. ——— Studien zur urgeschichte des wirbelthierkörpers. Mitth. zool. stat. Neapel, v,102-195, taf. v-xi. **84.1.**
657. ——— Studien zur urgeschichte des wirbelthierkörpers; xi. Spritzlochkieme der selachier, kiemendeckelkieme der ganoiden, pseudobranchie der teleostier. Mitth. zool. stat. Neapel, vii, 128-196, taf. ii-iii. **86.1.**
658. ——— Studien zur urgeschichte des wirbelthierkörpers; xii. Thyreoidea und hypobranchialrinne, spritzlochsack und pseudobranchialrinne bei fischen, Ammocoetes und tunicaten. Mitth. zool. stat. Neapel, vii, 301-338, taf. iv-v. **87.1.**
659. Eimer, G. H. T. Die entstehung der arten auf grund von vererben erworbener eigenschaften nach den gesetzen organischen wachsens; theil i. Jena, xii, 46 p., 8vo. **88.1.**
660. Fleischmann, A. Die stammesverwandtschaft der nager (Rodentia) mit den beutelthieren (Marsupialia). Sitzb. preuss. akad. wiss. Berlin, xvi, 299-305. **90.1.**
661. Gaskell, W. H. On the origin of vertebrates from a crustacean-like ancestor. Q. J. M. S., xxxi, 379-444, pls. xxv-xxviii. **90.1.**
662. Gruber, August. Die urahnen des tier- und pflanzenreichs. Humbolt, vi, 296-298. **87.1.**
663. Gulick, J. T. Intensive segregation or divergence through independent transformation. Journ. Linn. soc., zool. xxiii, 312-380. **90.1.**
664. Haacke, W. Ueber die entstehung des säugethiers. Biol. centralbl., viii, 8-16. **88.1.**
665. Hubrecht, A. A. W. On the ancestral form of the Chordata. Q. J. M. S., xxiii, 349-368, pl. xxiii. **83.1.**
666. ——— The relation of the Nemertea to the Vertebrata. Q. J. M. S., xxvii, 605-644, pl. xlii. **87.1.**
667. Huxley, T. H. Lectures on the evidence as to the origin of existing vertebrate animals. Nature, xiii, 388-410; 429-467; 514; xiv, 33. **76.1.**
668. Hyatt, Alpheus. Genesis of the Arietidae. Smithson. contrib., no. 673, xi, 238 p., pls. i-xiv. **89.1.**
669. Kielmeyer, Carl Friedrich. Ueber die verhältnisse der organischen kräfte unter einander in der reihe der verschiedenen organisationen, die gesetze und folgen dieser verhältnisse. Tübingen, 48 p. 12mo. **14.1.**
670. Kupffer, C. Die stammverwandtschaft zwischen ascidien und wirbelthieren; nach untersuchungen über die entwicklung der Ascidia canina (zool. dan.). Arch. f. mikr. anat., vi, 115-172, taf. viii-x. **70.1.**
671. Lameere, A. L'origine des vertébrés. Bull. soc. belg. micr., xvii, 91-121. **91.1.**
672. Löwe. Zur descendenztheorie. Verh. phys. ges. Berlin, 1875–6, 567. **78.4.**
673. McNeil, J. The male element the originating factor in the development of species. Psyche, v, 269-272. **89.1.**
674. Minot, C. S. Is man the highest animal? Proc. Am. assoc. adv. sc., xxx, 240-242. **82.35.**
675. Mivart, St. George. On the possibly dual origin of the Mammalia. Proc. roy. soc., xliii, 372-379. **88.1.**
676. Morse, E. S. Man in the tertiaries. Proc. Am. assoc. adv. sc., xxxiii, part 2, 579-591. **84.2.**
677. Osborn, Henry F. On the structure and classification of the mesozoic Mammalia. (Abstract.) Proc. acad. nat. sc. Philadelphia, 282-292. **87.2.**
678. Packard, A. S. Aspects of the body in vertebrates and arthropods. Am. nat., xviii, 855-861. **84.1.**

679. Packard, A. S. On certain factors of evolution. Am. nat. xxii, 808-821. **88.1**.
680. Parker, W. K. On mammalian descent. (The Hunterian lecture for 1884.) London, 236 p. ill. **84.1**.
681. ——— On mammalian descent. London, 229 p. 8vo. **85.1**.
682. Patten, Wm. On the origin of vertebrates from arachnids. Q. J. M. S., xxxi, 317-378, pls. xxiii-xxiv. **90.1**.
683. Ryder, J. A. Proofs of the effects of habitual use in the modification of animal organisms. Proc. Am. phil. soc., xxvi, 541-549. **89.2**.
684. Salensky, W. Die urform der heteroplastiden. Biol. centralbl., vi, 514-525. **86.1**.
685. Scharff, Robert F. Review of Dohrn's theories on the origin of vertebrates. Sc. proc. roy. Dublin soc., n. s. vi, pt. 1, 14-38. **88.1**.
686. Schimkewitsch, W. Ueber die morphologische bedeutung der organsysteme der enteropneusten. Anat. anz., v, 29-32. **90.1**.
687. Schlosser, Max. Die fossilen affen; referat über die monographie der affen, lemuren, chiropteren, insectivoren und fleischfresser des europäischen tertiärs. Arch. f. anthrop., xvii, 279-301, taf. xii. **87.1**.
688. Scott, W. B. On the osteology of Mesohippus and Leptomeryx with observations on the modes and factors of evolution in the Mammalia. Journ. morph., v, 301-406, pls. xxii-xxiii. **91.1**.
689. Shore, T. W. Relations of the Mammalia to the Ichthyopsida and Sauropsida. Journ. anat. phys., xxi, 362-373. **87.1**.
690. Spengel, J. W. Die stellung des menschen in der reihe der organismen. Bremen, 32 p. 1 taf. 12mo. **86.1**.
691. Sutton, J. B. On hypertrophy and its value in evolution. Proc. zool. soc. Lond., 432-445. **85.1**.
692. Vogt, J. G. Die menschwerdung; die entwickelung des menschen aus der hauptreihe der primaten und die begründung der weiten kluft zwischen tier und mensch abschliessend mit der vollständigen lösung des willensproblems, des problems der juridischen verantwortlichkeit und des teleologischen prinzipes in der menschlichen weiterentwickelung. Leipzig, iv, 392 p. 8vo. **92.1**.
693. Wagner, Moriz. Die entstehung der arten durch räumliche sonderung. Gesammelte aufsätze. Basel, 667 p. 8vo. **89.1**.
694. Wekerle, Ladisl. Urentstehung und leben der organismen. Leipzig, xiv, 104 p. 1 taf. 8vo. **81.1**.
695. White, W. Hale. A theory to explain the evolution of warm blooded vertebrates. Journ. anat. and phys., xxv, 374-385. **91.1**.
696. Wiedersheim, R. Der bau des menschen als zeugniss für seine vergangenheit. Freiburg i. B., 114 p. **87.1**.
697. Zacharias, O. Ueber den ursprung der ersten wirbelthiere. Centralbl. f. med. wiss., xvi, 67-70; 82-85. **78.1**.

EYE.

698. Ammon, von. Die entwickelungsgeschichte des menschlichen auges. Arch. f. ophthalm. Berlin, iv, 1-226, pls. i-xi. **58.1**.
699. Arnold, J. Beiträge zur entwicklungsgeschichte des auges. Heidelberg, vi, 79 p., pls. i-iv. **74.1**.
700. Angelucci, A. Ueber entwicklung und bau des vorderen uvealtractus der vertebraten. Arch. f. mikr. anat., xix, 152-182, taf. vii-ix. **81.1**.
701. Babuchin. Vergleichend histologische studien, nebst einem anhange zur entwicklungsgeschichte der retina. Würzburg naturw. zeitschr., v, 127-143, taf. iv. **65.1**.
702. Bambeke, Charles von. Contribution à l'histoire du développement de l'oeil humain. Ann. soc. méd. Gand, 1-22. **79.1**.
703. Barkau, A. Beiträge zur entwicklungsgeschichte des auges der batrachier. Sitzb. Wien. akad., liv, 70-74, taf. 1. **66.1**.
704. Bergmeister, O. Beiträge zur entwicklungsgeschichte des säugethierauges. Mitth. embryol. inst. univ. Wien, 1, 63-84, taf. vi-vii. **80.1**.
705. Bernheimer, Stefan. Ueber die entwickelung und den verlauf der markfasern um chiasma nervorum opticorum des menschen. Arch. f. augenheilk. Wiesbaden, xx, 133-179, pl. i. **89.1**.
706. Ciaccio, G. V. Sull' origine e struttura dell' umore vitreo specialmente negli embrioni delle due prime classi de' vertebrati. Rend. accad. sc. Bologna, 172-173. **78.1**.
707. Dogiel, Alex. S. Die retina der ganoiden. Arch. f. mikr. anat., xxii, 419-472, taf. xvii-xix. **83.1**.
708. ——— Ueber die nervösen elemente in der retina des menschen. Arch. f. mikr. anat., xxxviii, 317-344, taf. xix-xxii. **92.1**.
709. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; ix. Die bedeutung der unpaaren flosse für die beurtheilung der genealogischen stellung der tunicaten und des Amphioxus und die reste der beckenflosse bei Petromyzon. x. Zur phylogenese des wirbelthierauges. Mitth. zool. stat. Neapel, vi, 399-480, taf. xxiii-xxiv. **86.2**.
710. Duval, M. Sur l'origine embryonnaire de la région dite lenticulo-optice. Gaz. méd. Paris, 375 p. **79.1**.
711. Evetzky, Th. v. Beiträge zur entwickelungsgeschichte des auges. Arch. f. augenheilk. Wiesbaden, viii, 305-356, taf. iii. **79.1**.

712. Evetzky, Th. v. Zur entwickelungsgeschichte des thränennasenganges beim menschen. Arch. f. ophthalm. Leipzig, xxiv, abth. 1, 23-35, pl. i. **88.1**.
713. Falchi, F. Sull' istogenesi della retina e del nervo ottico. Ann. ottalm. Pavia, xv, 528-530. **87.1**.
714. ——— Sur l'histogénèse de la retine et du nerf optique. Arch. ital. biol., ix, 382-399, pl. i. **87.2**.
715. Froriep, Aug. Ueber die entwickelung des sehnerven. Anat. anz., vi, 155-161. **91.1**.
716. Gottschau. Zur entwicklung der säugetierlinse. Anat. anz., i, 381-382. **86.1**.
717. Haensell, P. Contribution à l'étude de l'embryogénie du cristallin. Bull. clin. nat. ophth. Paris, v, 147-150. **87.1**.
718. Hiltner, L. Ueber die entwicklung des nervus opticus der säugethiere. Biol. centralbl., v, 38-40. **85.1**.
719. Hunt, David. A comparative sketch of the early development of the ear and eye in the pig, together with a new account of the development of the meatus externus, drum, and Eustachian tube. Rep. 1st congress intern. otolog. soc. New York, 104-112. **77.1**.
720. Huschke, E. Ueber die erste entwickelung des auges und die damit zusammenhängende cyklopie. Meckel's Arch. anat. u. phys., 1-47, taf. i. **32.1**.
721. ——— Ueber einige streitpuncte aus der anatomie des auges. Ammon's Zeitschr. f. opthalm., iv, 271-295. **35.1**.
722. Karanyi, Alex. Beiträge zur entwickelung der krystallinse bei den wirbeltieren. Intern. monatsschr. anat. histol., iii, 226-246, taf. ix-xi. **86.1**.
723. Keibel, Franz. Zur entwickelung des glaskörpers. His's Arch., anat. abth., 358-369, taf. xvii. **86.1**.
724. ——— Ueber die entwickelung des sehnerven. Deutsch. med. wochenschr., xv, 116. **89.1**.
725. Kennel, J. v. Ueber die ableitung der vertebratenaugen von den augen der anneliden. Sitzb. Dorpat. naturf. ges., 408-411. **91.4**.
726. Kessler, L. Untersuchungen über die entwicklung des auges, angestellt am hühnchen und Triton. Dorpat. **71.1**.
727. ——— Ueber die entwicklung des glaskörpers beim hühnchen. Dorpat. med. zeitschr., v, 359-360. **74.1**.
728. ——— Ueber die entwicklung der linsenkapsel. Dorpat. med. zeitschr., vi, 70. **75.1**.
729. ——— Zur entwicklung des auges der wirbelthiere. Leipzig, Vogel, 112 p., taf. i-vi. 4to. **77.1**.
730. Kölliker, A. Ueber die entwicklung der linse. Z. Z., vi, 142-143. **55.1**.
731. ——— Zur entwicklung des auges und geruchsorganes menschlicher embryonen. Verh. phys.-med. ges. Würzburg, n. f., xvii, 229-257, pl. x-xiii. **83.3**.
732. Lieberkühn, N. Ueber das auge des wirbelthier-embryo. Schrift. ges. beförd. naturw. Marburg, x, 299-381, taf. i-xi. **72.1**.
733. ——— Ueber die augenblasenspalte. Sitzb. ges. beförd. naturw. Marburg, 35-37. **73.1**.
734. ——— Zur anatomie des embryonalen auges. Sitzb. ges. beförd. naturw. Marburg, 125-132. **77.1**.
735. ——— Beiträge zur anatomie des embryonalen auges. Arch. f. anat. u. phys., 1-29, taf. i-ii. **79.2**.
736. Löwe, L. Die histogenese der retina nebst vergleichenden bemerkungen über die histogenese des central-nervensystems. Arch. f. mikr. anat., xv, 596-630, taf. xxxvii. **78.1**.
737. ——— Beiträge zur anatomie des auges. Arch. f. mikr. anat., xv, 542-595, taf. xxxiv-xxxvi. **78.3**.
738. Manz. Entwicklungsgeschichte des menschlichen auges. Handb. ges. augenheilk. Leipzig, ii, theil 2, 1-57. **76.1**.
739. Martin, Paul. Zur entwickelung der netzhaut bei der katze. Zeitschr. f. vergleich. augenheilk., vii, 25-41. **91.1**.
740. Mihalkowics, V. von. Ein beitrag zur ersten anlage der augenlinse. Arch. f. mikr. anat., xi, 379-388, taf. xxi. **74.3**.
741. Müller, W. Ueber die stammesentwicklung des sehorgans der wirbelthiere. Beitr. anat. phys. als festgabe Carl Ludwig, 15 Oct., 1874, gewidmet von seinen schülen, Leipzig, heft 2, i-lxxvi, taf. x-xiv. **74.1**.
742. Nuel, J. T. Du développement phylogénétique de l'organe visuel des vertébrés. Arch. de biol., vii, 389-410. **87.1**.
743. Rabattel, R. Recherches sur le développement du cristallin chez l'homme et quelques animaux supérieurs. Recueil zool. suisse, ii, 203-231, pls. vii-viii. **85.1**.
744. Radwaner, J. Ueber die entwicklung der sehnervenkreuzung. Mitth. embryol. inst. univ. Wien, i, 21-36, taf. iii-iv. **80.1**.
745. Real y Beyro, M. Contribution à l'étude de l'embryologie de l'oeil. Paris, 143 p., pls. iv, 4to. (Thèse.) Abstract: Revue d. sc. méd., no. 52. **85.1**.
746. Retzius, G. Beiträge zur kenntniss der inneren schichten der netzhaut des auges. Biol. unters. Stockholm, i, 89-104, taf. i. **81.3**.
747. Richiardi, S. Sopra il sistema vascolare sanguifero dell' occhio del feto umano e dei mammiferi. Arch. zool. anat. fis., ser. 2, i, 193-210, taf. 1. **69.1**.
748. Rieke, A. Ueber formen und entwickelung der pigmentzellen der Chorioidea. Arch. f. ophthalm., xxxvii, abth. 1, 62-96. **91.1**.
749. Schenk, S. L. Zur entwicklungsgeschichte des auges der fische. Sitzb. Wien. akad., lv, 480-492, taf. i-ii. **67.2**.
750. Schoeler, H. De oculi evolutione in embryonibus gallinaceis. Dorpati Livonorum, 35 p., 1 pl. 4to. (Inaug. diss.) **48.1**.
751. Schultze, Max. Zur anatomie und physiologie der retina. Arch. f. mikr. anat., ii, 175-286, taf. viii-xv. **66.1**.
752. ——— Bemerkungen über bau und entwickelung der retina. Arch. f. mikr. anat., iii, 371-382. **67.1**.
753. Schultze, O. Ueber die entwickelung der netzhautgefässe. Verh. anat. ges., v, 174-180. **91.1**.

754. Seiler, H. Zur entwickelung des conjunctivalsacks. Arch. f. anat. u. phys., anat. abth., 236-249, taf. xiii. **90.1.**
755. Sharp, Benj. Homologies of the vertebrate crystalline lens. Proc. acad. nat. sc. Philadelphia, 300-310. **84.1.**
756. Todaro, F. Sur l'origine phylogénétique des yeux des vertébrés et sur la signification des épiphyses et des hypophyses de leur cerveau; de la fasse ciliée et de la glande de Hancook des tuniciers. Arch. ital. biol., ix, 55-57. **88.1.**
757. Vassaux. Recherches sur les premières phases du développement de l'oeil chez le lapin. Arch. d'ophthalm. Paris, viii, 523-547. **88.1.**
758. Willard, P. Ueber die entwicklung der krystallinse bei säugethieren. Osterwieck, 35 p., 8vo. **87.1.**
759. Würzburg, A. Beitrag zur bildungsgeschichte der iris und retina beim kaninchen. Centralbl. f. med. wiss., 820-823. **75.1.**

FACE.

760. Broca, A. Contribution à l'étude du développement de la face; études sur le bec-de-lièvre complexe de la lèvre supérieure. Ann. gynéc., xxviii, 81-97, 241-272. **87.1.**
761. Brock, J. Ueber die entwicklung des unterkiefers der säugethiere. Z. Z., xxvii, 287-318, taf. xix-xx. **76.1.**
762. Callender, G. W. The formation and early growth of the bones of the human face. Phil. trans. roy. soc. Lond., clix, 163-172, pls. xiii-xiv. **70.1.**
763. Fox, L. W. Die asymmetrie des gesichtes bei menschlichen embryonen. Mitth. embryol. inst. Wien., i, 279-285. **80.1.**
764. Parker, W. K. On the development of the face in the sturgeon (Acipenser sturio). Month. micr. journ., ix, 254-257, pl. xx. **73.3.**

FAT.

765. Bizzozero, G. Ueber die atrophie der fettzellen des knochenmarks. Arch. f. mikr. anat., xxxiii, 247-254, taf. xvi. **89.1.**
766. Bobritzky, C. Zur kenntniss des baues, der entwickelung und der regressiven metamorphose der fettzellen. Centralbl. f. med. wiss. Berlin, xxiii, 753-755. **85.1.**
767. Borden, W. C. The origin and development of the fat cell of the frog (Rana halecina). Microscope, ix, 101-105, pl. v. **89.1.**
768. Flemming, W. Ueber bildung und rückbildung der fettzelle im bindegewebe. Arch. f. mikr. anat., vii, 32-80, taf. vi-viii. **71.1.**
769. ——— Weitere mittheilungen zur physiologie der fettzelle. Arch. f. mikr. anat., vii, 328-371, taf. xxviii. **71.2.**
770. ——— Ueber die entwickelung der fettzellen und des fettgewebes. Arch. f. anat. u. phys., anat. abth., 401-454, taf. xvi. **79.1.**
771. Frommann, C. Structur der fettzellen und ihre membran; no. xiii aus dem Untersuchungen über structur, lebenserscheinungen und reactionen thierischer und pflanzlicher zellen. Jen. zeitschr. f. naturw., n. f. x, 217-220. **84.3.**
772. Gaule, Justus. Ueber das auftreten von fett in den zellen und die dadurch bedingten histologischen bilder. Arch. f. anat. und phys., phys. abth., 551-553. **90.1.**
773. Hoggan, G., *and* Hoggan, Fr. E. On the development and retrogression of the fat cell. Journ. roy. micr. soc., ii, 353-380, pls. xiii-xiv. **79.1.**
774. Kölliker, A. von. Zur entwickelung des fettgewebes. Anat. anz., i, 203-208. **86.1.**
775. Poljakoff, P. Ueber eine neue art von fettbildenden organen im lockern bindegewebe. Arch. f. mikr. anat., xxxii, 123-186, taf. i-iii. **88.1.**
776. Schöbl, J. Ueber wundernetzbildungen im fettgewebe. Arch. f. mikr. anat., xxiv, 92-97, taf. v-vi. **85.1.**

FOETAL MEMBRANES.

777. Beneden, E. v., *and* Julin, Charles. Recherches sur la formation des annexes foetales chez les mammifères (lapin et cheiroptères). Arch. biol., v, fasc. 3, 369-434, pl. xx-xxiv. **84.1.**
778. Bergonzini, C. Osservazioni sopra gli annessi fetali di due embrioni umani di 13 e di 5 millimetri di lunghezza. Rassegna d. sc. med. Modena, vi, 373-388. **91.1.**
779. Bischoff, Th. L. W. Beiträge zur lehre von den eihüllen des menschlichen foetus. Bonn, 112 p. taf. i-ii. **34.1.**
780. Blacher, K. Ein beitrag zum bau der menschlichen eihüllen. Arch. f. gynäk., x, 459-469, taf. xi. **76.1.**
781. ——— Noch ein beitrag zum baue der menschlichen eihüllen. Arch. f. gynäk., xiv, 121-126, taf. ii. **79.1.**
782. Bonnet, R. Ueber die eihäute der wiederkauer. Sitzb. ges. f. morph. u. phys. München, ii, 58-73. **86.1.**
783. ——— Die eihäute des pferdes. Verh. anat. ges. Berlin, iii, 17-38. **89.3.**

784. Breschet, G. Recherches anatomiques et physiologiques sur la gestation des quadrumanes. Mém. acad. sc. Paris, xix, 401-490, pls. i-xiv. **45.1.**

785. Caldwell, W. H. On the arrangement of the embryonic membranes in marsupial animals. Q. J. M. S., xxiv, 655-658, pl. xliii. **84.1.**

786. Chabry, L., *and* Boulart, R. Note sur un foetus de dauphin et ses membranes. Robin's Journ. anat. et phys., xix, 572-575, pl. xxxix. **83.1.**

787. Chapman, Henry E. On a foetal kangaroo and its membranes. Proc. acad. sc. Philadelphia, 468-471, pl. xx. **81.1.**

788. ——— On a foetal kangaroo and its membranes. Ann. mag. nat. hist., ser. 5, ix, 338-340. **82.1.**

789. Dohrn, H. Ein beitrag zur mikroskopischen anatomie der reifen menschlichen eihüllen. Monatschr. f. geburtsk., xxvi, 114-127, taf. iv. **65.1.**

790. Duval, Mathias. Études histologiques et morphologiques sur les annexes des embryons d'oiseau. Robin's Journ. anat. et phys., xx, 201-241, pls. ix-xii. **84.2.**

791. Emanuel, R. Ueber eihautverhältnisse bei zwillingsschwangerschaft. Würzburg, 24 p. 8vo. (Diss.) **87.1.**

792. Hart, B. D., *and* Carter, J. T. A contribution to the sectional anatomy of advanced extrauterine gestation. Edinb. med. journ., xxxiii, 332-343, pls. i-iii. **87.1.**

793. Hennig, C. Ueber die eihüllen einiger säugethiere. Sitzb. naturf. ges. Leipzig, i, 9-12. **75.2.**

794. Klaatsch, Hermann. Die eihüllen von Phocaena communis Cuv. Arch. f. mikr. anat., xxvi, 1-50, taf. i-ii. **85.1.**

795. Krüger, R. Die beziehungen der entwickelung der menschlichen nachgeburtsorgane zu derjenigen der frucht. Schwerin, 19 p. 8vo. (Inaug. diss.) **77.1.**

796. Krukenberg, G. Ueber die durchlässigkeit der eihäute. Arch. f. gynäk., xxxiii, 443-448. **88.1.**

797. Kyburg, Bernhard. Beschreibung von foeten und peripheren eitheilen einer vierlingsgeburt nebst musterung der angaben über die geschlechtsverhältnisse der einem ei entstammenden foeten. Halle, 27 p., taf. i, 4to. (Diss.) **78.1.**

798. Langhans, Th. Ueber glykogen in pathologischen neubildungen und den menschlichen eihäuten. Virchow's Arch., cxx, 28-67. **90.1.**

799. Löwe, Ludwig. Zu sachen der eihäute jüngster menschlichen eier. Arch. f. gynäk., xiv, 190-196. **79.1.**

800. Meola, F. Sulla struttura degl' involucri del feto umano. Riv. intern. med. chir., i, 505-552; 582-609, tav. i. Abstract, Centralbl. f. gynäc., 1885, 584. **84.1.**

801. Milne-Edwards, A. Recherches sur les enveloppes foetales du taton à neuf bandes. C. R. Paris, lxxxviii, 406-408; Ann. sc. nat., viii. **79.1.**

802. ——— Sur la disposition des enveloppes foetales de l'aye-aye. C. R. Paris, xcix, 265-267. **84.1.**

803. Minot, C. S. Uterus and embryo; i. Rabbit. ii. Man. Journ. morph., ii, 341-462. **89.111.**

804. Mitsukuri, K. On the foetal membranes of Chelonia. Anat. anz., v, 510-519; Journ. coll. sc. univ. Japan, iv, 1-53, pls. i-x. **90.1.**

805. Nasse, O. Die eihülle der spitzmaus und des igels. Arch. f. anat. u. phys., 730-738, taf. xviiib, fig. 1-4. **63.1.**

806. Osborn, H. F. Observations upon the foetal membranes of the opossum and other marsupials. Q. J. M. S., xxiii, 473-484, pl. xxxiii. **83.2.**

807. ——— Upon the foetal membranes of the marsupials. Zool. anz., vi, 418-419. **83.3.**

808. ——— The foetal membranes of the marsupials. Journ. morph., i, 373-382, pl. xvii. **87.4.**

809. Owen, R. Description of the membranes of the uterine foetus of the kangaroo. Mag. nat. hist., i, 481-484. **37.1.**

810. ——— Description of the foetal membranes and placenta of the elephant (Elephas indicus Cuv.) with remarks on the value of placentary characters in the classification of the Mammalia. Phil. trans. roy. soc. Lond., cxlvii, 347-353. **57.1.**

811. Ravn, Edward. Ueber die mesodermfreie stelle in der keimscheibe des hühner-embryos. His's Arch., anat. abth., 412-421, taf. xxi. **86.1.**

812. Robin, H. A. Sur la morphologie des enveloppes foetales des cheiroptères. C. R. Paris, xcii, 1354-1357. **81.1.**

813. Ruge, Carl. Die eihüllen in der geburt befindlichen uterus; bemerkungen über den ort und die art der ernährung des kindes in demselben. *In* Schröder, H. Der schwangere und kreissende uterus. Bonn, 113-151. **86.1.**

814. Turner, Wm. On the gravid uterus and on the arrangement of the foetal membranes in the Cetacea. Trans. roy. soc. Edinburg, xxvi, 467-504, pl. xvii-xviii. **72.1.**

815. ——— Note on the foetal membranes of the reindeer (Rangifer tarandus). Journ. anat. phys., xii, 601-603. **78.1.**

816. ——— On the foetal membranes of the eland (Oreas canna). Journ. anat. phys., xiv, 241-243. **79.2.**

817. Walker, A. Der bau der eihäute bei graviditatis abdominalis. Virchow's Arch., cxvii, 72-99, taf. ii. **87.1.**

GANGLIA.

818. Gaule, Justus. Spinalganglien und haut. Centralbl. f. phys., v, 690-697. **92.1.**

819. Goldberg, Max. Ueber die entwickelnng der ganglien beim hühnchen. Arch. f. mikr. anat., xxxvii, 587-602, taf. xxii. **91.1.**

820. Golowine, F. Sur le développement du système ganglionnaire chez le poulet. Anat. anz., v, 119-124. **90.1.**

821. Lahousse. Recherches histologiques sur la genèse des ganglions et des nerfs spinaux. (Rapport par van Bambeke.) Bull. acad. méd. belge, sér. 3, xix. **85.1**.
822. Lenhossék, M. v. Die entwickelung der ganglienanlagen bei dem menschlichen embryo. Arch. f. anat. u. phys., anat. abth., 1-25, taf. i. **91.1**.
823. ——— Ursprung, verlauf und endigung der sensibeln nervenfasern bei Lumbricus. Arch. f. mikr. anat., xxxix, 102-136, taf. v. **92.1**.
824. Rawitz, B. Ueber den bau der spinalganglien; i. Die struktur der zellen. Arch. f. mikr. anat., xviii, 283-301, taf. xv. **80.1**.
825. Schwalbe, G. Ueber den bau der spinalganglien nebst bemerkungen über die sympathischen ganglienzellen. Arch. f. mikr. anat., iv, 45-72, taf. iv. **68.1**.
826. Staehly, August. Zur histogenese der ganglia. Würzburg, 26 p. 8vo. (Med. inaug. diss.) **89.1**.

GANOIDS.

827. Balfour, F. M., *and* Parker, W. N. On the structure and development of Lepidosteus. Phil. trans. roy. soc. Lond., clxxiii, 359-442, pls. xxi-xxix. **82.1**.
828. Beard, J. On the early development of Lepidosteus osseus. Proc. roy. soc. Lond., xlvi, 108-118. **89.2**.
829. Kowalewsky, Owsjannikow, *and* Wagner, N. Die entwicklungsgeschichte der störe. Bull. acad. St. Pét., xiv, 317-325. **70.1**.
830. Mark, E. L. Studies on Lepidosteus; part i. Bull. mus. comp. zool., xix, 1-127, pls. i-ix. **90.1**.
831. Ryder, J. A. On the development of the common sturgeon (Acipenser sturio). Am. nat., xxii, 659-660. **88.1**.
832. ——— The sturgeons and sturgeon industries of the eastern coast of the United States, with an account of experiments bearing upon sturgeon culture. Bull. U. S. fish comm., viii (1888), 231-328, pls. 38-49. **90.2**.
833. Salensky, W. Zur embryologie der ganoiden; i. Befruchtung und furchung des sterlet-eies. Zool. anz., i, 243-245. **78.1**.
834. ——— Development of the sterlet (Acipenser ruthenus); 2 parts. Proc. soc. imp. univ. Kasan, vii, 10,545 p., 19 taf. **80.2**.
835. ——— Recherches sur le développement du sterlet (Acipenser ruthenus). Arch. de biol., ii, 233-341, taf. xv-xviii. **81.1**.

GASTRULA THEORY

836. Bütschli, O. Bemerkungen zur gastraeatheorie. Morph. jahrb., ix, 415-427, taf. xx. **83.2**.
837. Claus, C. Die typenlehre und C. Haeckel's sog. gastraea theorie. Wien, 30 p. **74.1**.
838. Lankester, E. R. On the development of the pond-snail. Q. J. M. S., xiv, 374-391. **74.1**.
839. Metschnikoff, Elias. Vergleichend-embryologische studien. Z. Z., xxxvi, 433-444, taf. xxviii. **82.2**.
840. ——— Embryologische studien an medusen; ein beitrag zur genealogie der primitivorgane. Wien, vi, 159 p., atlas fol. taf. xii. **86.1**.
841. Smith, Frank. The gastrulation of Aurelia flavidula. Bull. mus. comp. zool., xxii, 115-125, pls. i-ii. **91.1**.

GENERAL WORKS.

842. Baer, K. E. von. Ueber entwickelungsgeschichte der thiere; beobachtung und reflexion; erster theil. Königsberg, xxii, 271 p. taf. i-iii. 4to. **28.2**. Zweiter theil, 315 p. taf. iv-vii. **37.1**. Schlussheft, herausg. von Prof. Dr. L. Stieda, pp. 319-400. **88.1**.
843. Balbiani, G. Leçons sur la génération des vertébrés; recueillies par le Dr. F. Henneguy, revues par le professeur. Cours d'embryogénie comparée du collége de France (semestr. d'hiver, 1877-'78). Paris, vi, 279 p., pls. i-vi. **79.1**.
844. Barry, Martin. Researches in embryology; first series. Phil. trans. roy. soc. Lond., 301-341, pls. v-viii. **38.1**.
845. ——— Researches in embryology; second series. Phil. trans. roy. soc. Lond., 307-380, pls. v-ix. **39.1**.
846. ——— Researches in embryology; third series. A contribution to the physiology of cells. Phil. trans. roy. soc. Lond., 529-612, pls. xxix-xxx. **40.1**.
847. Bischoff, Th. L. W. Entwicklungsgeschichte der säugethiere und des menschen. Leipzig, 575 p. **42.3**
848. Bonnet, R. Grundriss der entwickelungsgeschichte der haussäugetiere. Berlin, 282 p. 8vo. **91.1**.
849. Carus, C. G. Tabulae anatomiam comparativam illustrantes: Erläuterungstafeln zur vergleichenden anatomie. Leipzig, heft i-iii, 1826-31. fol. **31.1**.
850. Coste, Jean Jacques M. C. V. Embryogénie comparée; cours sur le développement des animaux, etc. Paris, v, 479 p. atlas 4to. **37.1**.
851. ——— Histoire générale et particulière du développement des corps organisés. (Each plate is given twice, once in outline lettered, once colored without letters. Thirteen pairs of plates relate to human embryology.) Paris, i, 1847, ii (une fascicule), 1859, 4to; atlas fol., pls. i-l. **47.1**.
852. Debierre, Ch. Manuel d'embryologie humaine et comparée. Paris, x, 794 p. 8 pls. **86.1**.
583. Deschamps. Cours sur la génération, l'ovologie et l'embryologie. Paris, 190 p., pls. i-x. 4to. **56.1**.

854. Duval, Mathias. Atlas d'embryologie. Paris, 116 p. pls. i-xl. 8vo. **89.2.**
855. Ecker, Alexander. Icones physiologicae: Erläuterungstafeln zur physiologie und entwickelungsgeschichte (taf. xxv-xxxi betreffen die entwickelungsgeschichte des menschen). Leipzig, 31 taf. mit erklärung. 4to. **51.1.**
856. Erdl, M. P. Die entwicklung des menschen und des hühnchens im eie zur gegenseitigen erläuterung nach eigenen beobachtungen zusammengestellt. (Erster band, theil 1, hühnchen; theil 2, menschen.) Leipzig, 144 p. theil 1, 13 taf., theil 2, 17 taf., 4to. **46.1.**
857. Gilis, P. Précis d'embryologie adapté aux sciences médicales. Paris, xxi, 454 p. 175 fig. **91.1.**
858. Haddon, Alfred C. An introduction to the study of embryology. Philadelphia and London, ix, 336 p. **87.3.**
859. Haeckel, E. Anthropogenie oder entwicklungsgeschichte des menschen; gemeinverständliche wissenschaftliche vorträge über die grundzüge der menschlichen keimes- und stammes-geschichte. Leipzig, xvi, 732 p. pls. i-viii. **74.1.**
860. ——— Die gastraea-theorie; die phylogenetische classification des thierreichs und die homologie der keimblätter. Jen. zeitschr. f. naturw., viii, 1-55, taf. i. **74.2.**
861. ——— Die gastrula und die eifurchung der thiere. Jen. zeitschr. f. naturw., ix, 402-508, taf. xix-xxv. **75.1.**
862. ——— Biologische studien; heft 2. Studien zur gastraea-theorie. Jena, 270 p. taf. i-xiv. **77.1.**
863. Hensen, V. Physiologie der zeugung (zugleich als vi bd. ii th. von Hermann's Handbuch der physiologie erschienen). Leipzig, viii, 304 p. 8vo. **81.1.**
864. Hertwig, Oscar. Lehrbuch der entwickelungsgeschichte des menschen und der wirbelthiere. Jena, 1888, 507 p. taf. i-ii. **88.1.** Dritte auflage, Jena, 1890, xiii, 554 p.
865. His, W. Ueber die bedeutung der entwicklungsgeschichte für die auffassung der organischen natur. (Rectoratsrede.) Leipzig, 40 p. **70.1.**
866. ——— Unsere körperform und das physiologische problem ihrer entstehung. Leipzig, 224 p. **74.1.**
867. ——— Anatomie menschlicher embryonen; i. Embryonen des ersten monats. Leipzig, 184 p. 8vo. mit fol. atlas, 8 taf. **80.1.**
868. ——— Anatomie menschlicher embryonen; ii. Gestalt und grössen-entwicklung bis zum schluss des zweiten monats. Leipzig, 104 p. 67 fig. **82.2.**
869. ——— Anatomie menschlicher embryonen; iii. Zur geschichte der organe. Leipzig, 260 p. 156 fig., atlas fol., taf. ix-xiv. **85.1.**
870. ——— Ueber die methoden der plastischen rekonstruktion und über deren bedeutung für anatomie und entwickelungsgeschichte. Anat. anz., ii, 382-394. **87.1.**
871. ——— Ueber das photographiren von schnittreihen. Arch. f. anat. u. phys., anat. abth., 174-178. **87.2.**
872. ——— On the principles of animal morphology. Proc. roy. soc. Edinb., xv, 287-298. **88.4.**
873. Hoffmann, C. K. Reptilien (bd. vi, abth. 3 von Bronn's Thierreich, entwickelungsgeschichtlicher theil, 1872-1888). Heidelberg. **79.2.**
874. Huxley, F. H. On the classification of the animal kingdom. Q. J. M. S., xv, 52-56. **75.1.**
875. Hyatt, Alpheus. Larval theory of the origin of cellular tissues. Proc. Bost. soc. nat. hist., xxiii, 45-163. **84.1.**
876. Jhering, Hermann von. Ueber generations-wechsel bei säugethieren. His's Arch. Abstract, Biol. centralbl., vi, 532-539. **86.1.**
877. Jörg, J. C. G. Abbildungen der organe des thierischen körpers für die grundlinien zu einer allgemeinen physiologie des menschen und der thiere; theil i. Die weiblichen organe der zeugung und das ei in den verschiedenen thierclassen. Leipzig, 11 p. 4to, taf. i-ix, fol. **15.1.**
878. Kölliker, A. Untersuchungen zur vergleichenden gewebelehre, angestellt in Nizza im herbste 1856. Verh. phys.-med. ges. Würzburg, viii, 1-128, taf. i-iii. **58.1.**
879. ——— Entwicklungsgeschichte des menschen und der höheren thiere; zweite auflage. Leipzig, xxxiv, 1031 p. **79.2.**
880. ——— Grundriss der entwickelungsgeschichte des menschen und der höheren tiere; zweite auflage. Leipzig, viii, 454 p. **84.1.**
881. ——— Der jetzige stand der morphologischen disciplinen mit bezug auf allgemeine fragen; rede des vorsitzenden der anatomischen gesellschaft. Anat. anz., ii, 326-345. Separate: Jena, 25 p. **87.1.**
882. Lankester, E. R. On the primitive cell layers of the embryo as the genealogical classification of animals, and on the origin of vascular and lymph systems. Ann. mag. nat. hist., ser 4, xi, 321-338. **73.1.**
883. ——— Degeneration: a chapter on Darwinism. London, 75 p. 8vo. **80.1.**
884. Leuckart, R. Zeugung. Wagner's Handwörterb. d. phys., iv, 707-1000. **53.1.**
885. Leydig, Franz. Untersuchungen zur anatomie und histologie der thiere. Bonn, 174 p., taf. i-viii. **83.1.**
886. Longet, F. A. Traité de physiologie. (De la reproduction dans l'espèce humaine.) 3ème éd. Paris, iii, 731-990. **69.1.**
887. Marcacci, A. Influence du mouvement sur le développement des oeufs de poule. Arch. ital. biol., xi, 164-171. **89.1.**
888. Meckel, J. Fr. Beyträge zur vergleichenden anatomie; bd. i. Beyträge zur geschichte des menschlichen foetus. Leipzig, i, h. 1, 57-124, 8vo. **08.1.**

889. Müller, J. Handbuch der physiologie des menschen. Coblenz, 2v., 741 p., vi, 780 p. 8vo. **40-44.1.**
890. Owen, R. The anatomy of vertebrates; vol. i. Fishes and reptiles; vol. ii. Birds and mammals; vol. iii. Mammals. London, i, 650 p.; ii, 592 p.; iii, 915 p. **66-68.1.**
891. Prenant, A. Éléments d'embryologie de l'homme et des vertébrés. Paris, xxiii, 472 p., pls. i-iv, 229 figs. 8vo. **91.1.**
892. Rathke, H. Beiträge zur geschichte der thierwelt. (4 parts.) Neu. schrift. naturf. ges. Danzig, i, heft i, 136 p., taf. i-iv; 1824, 210 p., taf. v; 1825, 146 p., taf. iii; 1827, 129 p., taf. i-iii. 4to. **20.1.**
893. ——— Abhandlungen zur bildungs- und entwickelungsgeschichte des menschen und der thiere; theil i. Leipzig, vii, 114 p. taf. vii. 4to. **32.2.**
894. ——— Abhandlungen zur bildungs- und entwicklungsgeschichte des menschen und der thiere; theil ii. Leipzig, vi, 102 p. taf. vii. 4to. **33.1.**
895. ——— Entwicklungsgeschichte der wirbelthiere. Leipzig, viii, 201 p. 8vo. **61.1.**
896. Remak, R. Untersuchungen über die entwicklung der wirbelthiere. Berlin, 194, xxxvii p., taf. i-xii. **50-55.1.**
897. ——— Sur le développement des animaux vertébrés. C. R. Paris, xxxv, 341-349. **52.1.**
898. Reichert, K. B. Das entwicklungsleben im wirbelthier-reiche. Berlin, viii, 261 p. taf. i-v. 4to. **40.1.**
899. ——— Beiträge zur kenntniss des zustandes der heutigen entwicklungsgeschichte. Berlin, 137 p. **43.1.**
900. Romiti, Guglielmo. Lezioni di embriogenia umana e comparata dei vertebrati; parte i. Embriogenia generale. Siena, 211 p. 8vo. **81.1.**
901. ——— Lezioni di embriogenia umana e comparata dei vertebrati; p. ii. Embriogenia speciale od organogenesi; i. Sviluppo del sistema nervose. Siena, 70 p. 8vo. **82.1.**
902. ——— Notizie anatomiche, iv. Siena, 20 p. tav. i. **86.2.**
903. Roux, Wilhelm. Der kampf der theile im organismus; kap. v: Ueber das wesen des organischen. Leipzig, 210-235. **81.1.**
904. Ryder, J. A. On the availability of embryological characters in the classification of the Chordata. Am. nat., xix, 815-819; 903-907. **85.8.**
905. Salensky, W. Bemerkungen über Haeckel's gastraeatheorie. Arch. f. naturg., jahrg. 40, bd. i, 137-174, taf. v. **74.1.**
906. Schenk, S. L. Lehrbuch der vergleichenden embryologie der wirbelthiere. Wien, 198 p. taf. i-iii. **74.2.**
907. Schneider, A. Beiträge zur vergleichenden anatomie und entwicklungsgeschichte der wirbelthiere. Berlin, viii, 164 p. taf. i-xvi. **79 1.**
908. Schröder, Karl. Der schwangere und kreissende uterus; beiträge zur anatomie und physiologie der geburtskunde; unter mitwirkung von Dr. M. Hofmeier, Dr. C. Ruge und Dr. C. H. Stratz herausg. Bonn, 151 p. atlas taf. i-vi. **86.1.**
909. Schwalbe, G. Lehrbuch der anatomie des ohres. Erlangen, 282 p. **87 1.**
910. ——— Lehrbuch der anatomie des auges. Erlangen, 211 p. **87.2.**
911. Selenka, E. Studien über entwicklungsgeschichte der thiere; i. Keimblätter und primitivorgane des maus. Wiesbaden, 32 p. taf. i-iv. 12 m. 4to. **83.1.**
912. ——— Studien über entwicklungsgeschichte der thiere; ii. Die keimblätter der echinodermen. Wiesbaden, 61 p. taf. v-x. 4to. **83.2.**
913. ——— Studien über entwicklungsgeschichte der thiere; iii. Die blätterumkehrung im ei der nagethiere. Wiesbaden, 99 p. taf. xi-xvi. 4to. **84.1.**
914. ——— Studien über entwicklungsgeschichte der thiere; iv. Das opossum (Didelphys virginiana). Wiesbaden, 101-132 p. 9 col. taf. 4to. **86.1.**
915. ——— Studien über entwicklungsgeschichte der thiere; iv. Das opossum (Didelphys virginiana), hälfte 2. Wiesbaden, 133-172 p. taf. xxv, xxvii-xxx. 4to. **87.1.**
916. ——— Studien über entwicklungsgeschichte der thiere; v. hälfte 1. i: Beutelfuchs und kanguruhratte (Phalangista et Hypsiprymnus). ii: Zur entstehungsgeschichte des amnion. iii: Das kantjil (Tragulus javanicus). iv: Affen ostindiens. 173-206 p. taf. xxxi-xxxv, xxxvii-xxxviii. 4to. **91.2.**
917. Semper, E. Die stammesverwandtschaft der wirbelthiere und wirbellosen. Arb. zool.-zoot. inst. Würzburg, ii, 25-76, taf. iii-v, und eine xylographie. **75.1.**
918. ——— Die verwandtschaftbeziehungen der gegliederten thiere; iii. Strobilation und segmentation. Arb. zool.-zoot. inst. Würzburg, iii, 115-404, taf. v-xv. **76.3.**
919. Tourneux, F., *and* Hermann, G. Embryologie. Embryon. Dict. enc. sc. méd., xxxlii, 652-750. **86.1.**
920. Valentin, G. Handbuch der entwickelungsgeschichte des menschen, u. s. w. Berlin, xx, 658 p. 8vo. **35.1.**
921. ——— Die doppelt brechenden eigenschaften der embryonalgewebe. (Beiträge zur mikroskopie, ii.) Arch. f. mikr. anat., vii, 140-156. **72.1.**
922. Velpeau, A. A. L. M. Die embryologie und ovologie des menschen, oder beschreibende und iconographische geschichte der anatomie und physiologie des menschlichen eies. (Translated into German by Carl Schwalbe.) Ilmenau, 84 p. taf. i-xv. **34.1.**
923. Vrolik, W. Tabulae ad illustrandam embryogenesen hominis et mammalium, tam naturalem quam abnormen. Lipsiae, fol. **54.1.**
924. Wagner, R., *and others.* Handwörterbuch der physiologie mit rücksicht auf physiologische pathologie. Braunschweig, 1842-1853. 4 vols. in 5. **43 1.**

925. Wagner, R. Icones physiologicae. Atlas, 4to. taf. i-xxvii. **52.1.**
926. Waldeyer. Bemerkungen über die keimblätter und die primitivstreifen bei der entwicklung des hühner-embryo, Z. rat. med., xxxiv, 159-178, taf. x-xi. **69.1.**
927. Waldeyer, W. Eierstock und ei; ein beitrag zur anatomie und entwicklungsgeschichte der sexual-organe. Leipzig, 174 p. taf. i-vi. **70.1.**
928. Wiedersheim, R. Grundriss der vergleichenden anatomie der wirbelthiere; zweite auflage. Jena, xvi, 389 p. 8vo. **88.1.**

GENITALIA EXTERNAL.

929. Boas, J. E. V. Zur morphologie der begattungsorgane der amnioten wirbeltiere. Morph. jahrb., xvii, 271-287, taf. xvi. **91.1.**
930. Eichbaum, F. Untersuchungen über die entwicklung der schwellkörper des penis und der harnröhre. Deutsch. zeitschr. f. thiermed. Leipzig, xiii, 373-407. **86.1.**
931. Gadow, H. Remarks on the cloaca and on the copulatory organs of the Amniota. (Abstract.) Proc. roy. soc. Lond., xl, 266-267. **86.1.**
932. Gasser, E. Einige entwicklungs-zustände der männlichen sexualorgane beim menschen. Sitzb. Marburg. ges. 91-111. **84.1.**
933. Martin, P. Zur entwicklung der cavernösen körper des penis und der harnröhre bei der katze. Deutsch. zeitschr. f. thiermed., Leipzig, xvi, 133-136. **90.2.**
934. Roseulhetz, V. Beiträge zur entwicklungsgeschichte des genitalhöckers beim menschen und beim schweine. Berlin, 30 p. 8vo. **90.1.**
935. Schweigger-Seidel, F. Anatomische mittheilungen. (P. 219, Zur entwickelung des praeputiums; p. 228, Ueber die vorgänge bei der lösung der miteinander verklebten augenlider des foetus.) Virchow's Arch., xxxvii, 219-232, taf. v. **66.1.**
936. Tourneux, F. Sur le développement de la verge et spécialement du gland du prépuce et de la portion balanique du canal de l'urèthre chez l'homme. C. R. soc. biol. Paris, sér. 8, iv, 632-636. **87.1.**
937. ——— Sur le développement et l'évolution du tubercule génital chez le foetus humain dans les deux sexes. Journ. de l'anat. et la phys., xxv, 229-263, pls. viii-xiii. **89.1.**

GERM-LAYERS.

938. Assaky, G. Origine des feuillets blastodermiques chez les vertébrés. Paris, 136 p. **86.1.**
939. Balfour, F. M. The development and growth of the layers of the blastoderm. Q. J. M. S., xiii, 266-276, pls. xi-xii. **73.2.**
940. ——— On the disappearance of the primitive groove in the embryo chick. Q. J. M. S., xiii, 276-280, pls. xii, figs. 1-3, xiii. **73.3.**
941. ——— Essays on embryology; i. On the structure and homologies of the germinal layers of the embryo; ii. Larval forms; their nature, origin and affinities. Q. J. M. S., xx, 247-273; 381-407. **80.1.**
942. Balfour, F. M., *and* Deighton, F. A renewed study of the germinal layers of the chick. Q. J. M. S., xxii, 176-188. **82.1.**
943. Bambeke, Ch. van. Formation des feuillets embryonnaires et de la notocorde chez les urodèles. Bull. acad. Belg., sér. 2, l, 83-91. **80.2.**
944. Bellonci, Giuseppe. Blastoporo e linea primitiva dei vertebrati. Accad. d. linc., ser. 3, xix, 45 p., tav. i-vi. **84.1.**
945. Beneden, E. van. Recherches sur l'embryologie des mammifères; La formation des feuillets chez le lapin. Arch. de biol., i, 136-224, pls. iv-vi. **80.1.**
946. Brandt, Alexander. Commentare zur keimbläschentheorie des eies; i. Blastodermelemente und dotterballen der insecten. Arch. f. mikr. anat., xvii, 43-57, taf. iv. **80.1.**
947. ——— Commentare zur keimbläschentheorie des eies; ii. Das keimbläschen als primäre zelle; die amöboide beweglichkeit des keimbläschens und zellkerns besonders in ihren beziehungen zur eifurchung, befruchtung und kerntheilung. Arch. f. mikr. anat., xvii, 551-574. **80.2.**
948. Brook, G. On the origin of the hypoblast in pelagic teleostean ova. Q. J. M. S., xxv, 29-36, pl. iii. **85.1.**
949. ——— Relation of yolk to blastoderm in teleostean fish ova. Proc. roy. phys. soc. Edinb., ix, 187-193. **86.1.**
950. Budge, A. Ueber ein kanalsystem im mesoderm von hühnerembryonen. Arch. f. anat. u. phys., anat. abth., 320-327, taf. xiv. **80.1.**
951. Burckhardt, R. Doppelanlage des primitivstreifens bei einem hühnerei. Arch. f. anat. u. phys., anat. abth., 431-432. **88.1.**
952. Cunningham, J. T. On the nature and significance of the structure known as Kupffer's vesicle in teleostean embryos. Proc. roy. soc. Edinb., xiii, 4-14, pls. i-ii. **84.1.**
953. ——— The significance of Kupffer's vesicle with remarks on other questions of vertebrate morphology. Q. J. M. S., xxv, 1-14, pl. i. **85.1.**

954. Cunningham, J. T. On the relations of the yolk to the gastrula in teleosteans and in other vertebrate types. Q. J. M. S., xxvi, 1-38, pls. i-iv. **85.2**.
955. Dansky, J., *and* Kostenitsch, J. Ueber die entwicklungsgeschichte der keimblätter und des Wolff'schen ganges im hühnerei. Mém. acad. St. Pét., sér. 7, xxvii, no. 13, 1-25, taf. i-ii. **81.1**.
956. Disse, J. Die entwicklung des mittleren keimblattes im hühnerei. Arch. f. mikr. anat., xv, 67-94, taf. v. **78.1**.
957. Dönitz, W. Ueber das Remak'sche sinnesblatt. Müller's Arch , 600-622, taf. xv. **69.1**.
958. Dursy, E. Der primitivstreif des hühnchens. Lahr, 80 p., pls. i-iii. **67.1**.
959. Duval, M. Études sur la ligne primitive de l'embryon du poulet. Ann. sc. nat., sér. 6, vii, art. 17, 48 p., pls. xiii-xviii. **78.1**.
960. ——— De la formation du blastoderme dans l'oeuf d'oiseau. Ann. sc. nat., sér. 6, xviii, 1-208, pl. i-v. **84.1**.
961. Gasser E. Ueber den primitivstreif bei vogelembryonen. Sitzb. Marburg. ges., 100-103. **77.1**.
962. ——— Der primitivstreifen bei vogelembryonen (huhn und gans). Schrift. Marburg. ges., xi, 1-98, taf. i-x. **79.1**.
963. ——— Beiträge zur kenntniss der vogelkeimscheibe. Arch. f. anat. u. phys., anat. abth., 359-398. **82.2**.
964. ——— Der parablast und der keimwall der vogelkeimscheibe. Sitzb. Marburg. ges., 49-59. **83.1**.
965. Hamann, Otto. Ueber die entstehung der keimblätter; ein erklärungsversuch. Intern. monatsschr. f. anat. u. phys., vii, 255-267; 295-311, taf. xii. **90.1**.
966. Hertwig, O. Die entwicklung des mittleren keimblattes der wirbelthiere. Jen. zeitschr. f. naturw., xv, 286-340, taf. xii-xv. **82.1**.
967. ——— Die entwicklung des mittleren keimblattes der wirbelthiere. Jen. zeitschr. f. naturw., xvi, 247-328, taf. xiv-xviii. **83.1**.
968. His, W. Der keimwall des hühnereies und die entstehung der parablastischen zellen. Zeitschr. f. anat. u. entwick., i, 274-287. **76.2**.
969. ——— Zur frage von der zusammensetzung des embryo. Programm, Leipzig. 4to. **77.3**.
970. ——— Die lehre von einem bindesubstanzkeim (parablast); rückblick nebst besprechung einiger neuerer entwicklungsgeschichtlicher arbeiten. Arch. f. anat. u. phys., anat. abth., 62-108. **82.1**.
971. Hoffmann, C. K. Die bildung des mesoderms, die anlage der chorda dorsalis und die entwicklung des canalis neurentericus bei vogelembryonen. Veröff. durch d. acad. wiss. Amsterdam, ii, 109 p., taf. v. **83.3**.
972. Hubrecht, A. A. W. Die erste anlage des hypoblastes bei den säugetieren. Anat. anz., iii, 906-912. **88.2**.
973. Kerschner, L. Keimzelle und keimblatt. Zeitschr. wiss. zool., xlv, 672-693. Reprint: Arb. zool. inst. Graz, ii, 53-74. **87.1**.
974. Kidd, P. On some points in the early development of the hen's egg. Q. J. M. S., xvii, 160-169, pl. xii. **77.1**.
975. Kölliker, A. Zur entwicklung der keimblätter im hühnereie. Verh. phys.-med. ges. Würzburg, viii, 209-215. **75.1**.
976. ——— Sur la formation des feuillets germinatifs de l'embryon. Arch. sc. phys. et nat. Genève, sér. 3, x, 368-371. **83.1**.
977. ——— Ueber die nichtexistenz eines embryonalen bindegewebskeims (parablasts). Sitzb. phys.-med. ges. Würzburg, 14-18. **84.2**.
978. ——— Die embryonalen keimblätter und die gewebe (und nachtrag). Zeitschr. wiss. zool., xl, 179-213, taf. xi-xii; 356-357. **84.3**.
979. ——— Kollmann's akroblast. Zeitschr. wiss. zool., xli, 155-158. **85.3**.
980. Klein, E. Das mittlere keimblatt in seiner beziehungen zur entwicklung der ersten blutgefässe und blutkörperchen im hühnerembryo. Sitzb. Wien. akad., lxiii, 339-391, 6 taf. **71.1**.
981. Koller, C. Beiträge zur kenntniss des hühnerkeims im beginne der bebrütung. Sitzb. Wien. akad., lxxx, abth. 3, 316-329, taf. i. **79.1**.
982. ——— Untersuchungen über die blätterbildung am hühnerkeim. Arch. f. mikr. anat., xx, 174-211, taf. x-xii. **82.1**.
983. Kollmann, J. Der mesoblast und die entwicklung der gewebe bei wirbeltieren. Biol. centralbl., iii. 737-747. **84.1**.
984. ——— Der randwullst und der ursprung der stützsubstanz (und nachwort). Arch. f. anat. u. phys., anat. abth., 341-434; 461-465, taf. xvi-xviii. **84.3**.
985. ——— Ueber furchung an dem selachier-ei. Verh. naturf. ges. Basel, viii, 103-105. **86.1**.
985a. ——— Die geschichte des primitivstreifens bei den meroblastiern. Verh. naturf. ges. Basel, viii, 106-114. **86.3**.
986. Minot, C. S. Recent investigations of embryologists. Proc. Bost. soc. nat. hist., xix, 165-171. **77.17**.
987. Mitsukuri, K. On the paired origin of the mesoblast in vertebrate. Anat. anz., vi, 198-201. **91.1**.
988. ——— Further studies on the formation of the germinal layers in Chelonia. Journ. coll. sc. univ. Japan, v, 35-52, pls. ii-iv. **91.2**.
989. Mitsukuri, K., *and* Ishikawa, C. On the formation of the germinal layers in Chelonia. Journ. coll. sc. univ. Japan, i, 211-246, 4 pls. Q. J. M. S., xxvii. 17-48, pls. ii-v. **87.1**.
990. Peremeschko. Ueber die bildung der keimblätter im hühnereie. Sitzb. Wien. akad., lvii, 499-516. **68.1**.
991. Perenyi, Josef. Die entwicklung der keimblätter und der chorda in neuer beleuchtung. Anat. anz., iv, 587-592. **89.1**

992. Rabl, C. Ueber die bildung des mesoderms. Anat. anz., iii, 654-661. **88.1.**
993. ——— Ueber die differenzierung des mesoderms. Anat. anz., iii, 667-679. **88.2.**
994. Rauber, A. Ueber die embryonale anlage des hühnchens. Centralbl. f. med. wiss., xii, 786-788; xiii, 49-52; 257-259. **75.1.**
995. ——— Primitivrinne und urmund; beitrag zur entwicklungsgeschichte des hühnchens. Morph. jahrb., ii, 550-576, taf. xxxvii-xxxviii. **76.2.**
996. ——— Primitivstreif und neurula der wirbelthiere in normaler und pathologischer beziehung. Leipzig, vi, 85 p. 8vo. **77.1.**
997. ——— Gibt es stockbildungen (cormi) bei den vertebraten? Morph. jahrb., v, 167-190, taf. xii-xiii. **79.1.**
998. ——— Formbildung und formstörung in der entwickelung von wirbelthieren. Erster abschnitt: Die höheren grade der embryonalen formstörung. Morph. jahrb., v, 661-785; vi, 1-48, taf. xxxix-xli of vol. v. **80.1.**
999. ——— Formbildung und formstörung in der entwickelung von wirbelthieren. Zweiter abschnitt: Ueber achsenvermehrung. Morph. jahrb., vi, 129-184, taf. vii-x. **80.2.**
1000. Repiachoff. Zur morphologie des primitivstreifens. Zool. anz., vi, 365-367. **83.1.**
1001. ——— Bemerkungen über die keimblätter der wirbelthiere. Zool. anz., vi, 148-152. **83.2.**
1002. Omitted.
1003. Robinson, A., *and* Assheton, R. The formation and fate of the primitive streak, with observations on the archenteron and germinal layers of Rana temporaria. Q. J. M. S., xxxii, 451-504, pls. xxxiv-xxxv. **91.1.**
1004. Romiti, G. Studi di embriogenia; i. Contribuzione allo studio dello sviluppo dei foglietti embrionali. Rivista clin. Bologna, ser. 2, iii, 363-367. **73.2.**
1005. ——— Sur l'origine du mésoderme et ses rapports avec le vitellus. Arch. ital. biol., ii, 277-279. **82.1.**
1006. Rückert, J. Zur keimblattbildung bei selachiern. (Ein beitrag zur lehre vom parablast.) München, 58 p. **85.1.**
1007. ——— Ueber die anlage des mittleren keimblattes und die erste blutbildung bei Torpedo. Anat. anz., ii, 97-112; 154-176. **87.1.**
1008. ——— Weitere beiträge zur keimblattbildung bei selachiern. Anat. anz., iv, 353-374, taf. i. **89.2.**
1009. Ryder, John A. The archistome theory. Am. nat., xix, 1115-1121. **85.5.**
1010. Sarasin, P. Ueber die theorie des mesoderms von C. Rabl. Anat. anz., iv, 721-728. **89.1.**
1011. Schenk, S. L. Beitrag zur lehre von den organanlagen im motorischen keimblatte. Sitzb. Wien. akad., lvii, 189-202, taf. i-iii. **68.1.**
1012. ——— Anatomisch-physiologische untersuchungen. Wien, 51 p., 1 pl. 8vo. **72.2.**
1013. ——— Die keimblattlehre. Allgem. Wien. med. zeit., 85-86. **78.1.**
1014. ——— Embryologische mittheilungen. Anz. Wien. ges. ärzte. **79.1.**
1015. Schultze, O. Die entwicklung der keimblätter und der chorda dorsalis von Rana fusca. Zeitschr. wiss. zool., xlvii, 325-352, taf. xxviii-xxix. **88.1.**
1016. Schwarz, D. Untersuchungen des schwanzendes bei den embryonen der wirbelthiere. Zeitschr. wiss. zool., xlviii, 191-224, taf. xii-xiv. **89.1.**
1017. Schwink, F. Ueber die gastrula bei amphibieneiern. Biol. centralbl., viii, 29-31. **88.1.**
1018. Selenka, E. Das mesenchym der echiniden. Zool. anz., vii, 100-102. **84.2.**
1019. Strahl, H. Die ausbreitung des mittleren keimblattes. Sitzb. Marburg. ges., 22-24. **88.1.**
1020. Stricker, S. Mittheilungen über die selbstständigen bewegungen embryonaler zellen. Sitzb. Wien. akad., xlix, 471-476. **64.1.**
1021. Waldeyer, W. Archiblast und parablast. Arch. f. mikr. anat., xxii, 1-77. **83.1.**
1022. Whitman, C. O. A rare form of the blastoderm of the chick and its bearing on the question of the formation of the vertebrate embryo. Q. J. M. S., xxiii, 375-397, pls. xxiv-xxv. **83.1.**
1023. Wolff, W. Ueber die keimblätter des huhnes. Arch. f. mikr. anat., xxi, 45-64, taf. v. **82.1.**
1024. Ziegler, H. E. Der ursprung des mesenchymatischen gewebes bei den selachiern. Arch. f. mikr. anat., xxxii, 378-400, taf. xiii. **88.1.**
1025. Zumstein, J. J. Ueber das mesoderm der vogelkeimscheibe (huhn und ente). Bern, 56 p. (Inaug. diss.) **87.1.**

GESTATION.

1026. Braune, W., *and* Zweifel, P. Gefrierdurchschnitte in systematischer anordnung durch den körper einer hochschwangeren geführt. Leipzig, 8vo. atlas fol. **90.1.**
1027. Lataste, Fernand. Des variations de durée de la gestation chez les mammifères et des circonstances qui déterminent ces variations; théorie de la gestation retardée. C. R. soc. biol. Paris, sér. 9, iii, 21-162. **91.1.**

GILLS.

1028. Maurer, F. Die kiemen und ihre gefässe bei anuren und urodelen amphibien und die umbildungen der beiden ersten arterienbogen bei teleostiern. Morph. jahrb., xiv, 175-222, taf. ix-x. **88.1.**
1028a. Riess, J. Albin. Der bau der kiemenblätter bei den knochenfischen. Arch. f. naturgesch., jahrg. 47, bd. i, 518-550, taf. xvi-xviii. **81.1**

1029. Schenk, S. L. Die kiemenfäden der knorpelfische während der entwickelung. Sitzb. Wien. akad., lxxi, 227-238, 1 pl. **75.1**.

GILL CLEFTS.

1030. Baer, K. E. v. Ueber die kiemen und kiemengefässe in den embryonen der wirbelthiere. Meckel's Arch., 556-558. **27.2**.
1031. ——— Ueber die kiemenspalten der säugethier-embryonen. Meckel's Arch., 143-148. **28.3**.
1032. Bemmelen, J. F. van. Ueber vermuthliche rudimentäre kiemenspalten bei elasmobranchiern. Mitth. zool. stat. Neapel, vi, 165-184, taf. xi-xii **86.1**.
1033. ——— Die visceraltaschen und aortenbogen bei reptilien und vögeln. Zool. anz., ix, 528-532; 543-546. **86.2**.
1034. ——— Epitheelderivaten van den ventralen darmwand achter de kieuwspleten. Tijdschr. Nederland. dierk. vereen., ser. 2, ii, verslagen, xxxvii-xxxix. **89.2**.
1035. Beneden, E. van, *and* Julin, C. Des orifices branchiaux externes des ascidiens et la formation du cloaque chez Phallusia scabroides. Bull. acad. Belg., sér. 3, viii, 631-646. **84.3**.
1036. Cadiat. Du développement des fentes et arcs branchiaux chez l'embryon. Journ. de l'anat. et phys., xix, 38-58, pls. v-viii. **83.1**.
1037. Cusset, J. Étude sur l'appareil branchial des vertébrés et quelques affections qui en dérivent chez l'homme (fistules branchiales, kystes branchiaux, kystes dermoides). Paris, 236 p., 2 pls., 1 tab. 4to. **77.1**.
1038. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; vii. Entstehung und differenzirung des zungenbein- und kiefer-apparates der selachier; viii. Die thyreoidea bei Petromyzon, Amphioxus und tunicaten. Mitth. zool. stat. Neapel, vi, 1-92, taf. i-viii. **86.1**.
1039. ——— Studien zur urgeschichte des wirbelthierkörpers; xi. Spritzlochkieme der selachier, kiemendeckelkieme der ganoiden, pseudobranchie der teleostier. Mitth. zool. stat. Neapel, vii, 128-176, taf. ii-iii. **87.1**.
1040. Gadow, Hans. On the modifications of the first and second visceral arches with especial reference to the homologies of the auditory ossicles. Phil. trans. roy. soc. Lond., clxxix, 451-485, pls. lxxi-lxxiv. **88.1**.
1041. Garnier, R. von. Geschichtlicher überblick der lehre über die kiemenspalten und bogen. Zool. anz., xiii, 682-686; 708-715. **90.1**.
1042. Houssay, F. Études d'embryologie sur les vertébrés; iv. Les fentes branchiales, auditive, hyo-mandibulaire, spiraculaire et les somites mésoblastiques qui leur correspondent chez l'axolotl. Bull. sc. France et Belg., xxiii, 55-79, pls. i-iii. **91.1**.
1043. Huschke. Ueber die kiemenbogen und kiemengefässe beim bebrüteten hühnchen. Isis, xx, 402-403. **27.1**.
1044. Kastschenko, N. Das schicksal der embryonalen schlundspalten bei säugetieren. (Zur entwickelungsgeschichte des mittleren und äusseren ohres, der thyreoidea und der thymus; carotidenanlage.) Arch. f. mikr. anat., xxx, 1-26, taf. i-ii. **87.1**.
1045. ——— Das schlundspaltengebiet des hühnchens. His's Arch., 258-300, taf. xvii-xix. **87.2**.
1046. Kunkel, A. Die lageveränderung der pharyngealen tubenmündung während der entwickelung. Hasse's Anat. stud., i, 172-188, taf. viii. **70.1**.
1047. Liessner, E. Ein beitrag zur kenntniss der kiemenspalten und ihrer anlagen bei amnioten wirbeltieren. Morph. jahrb., xiii, 402-427, taf. xvi. **88.1**.
1048. Mall, Franklin P. Entwickelung der branchialbogen und -spalten des hühnchens. Arch. f. anat. u. phys., anat. abth., 1-34, taf. i-iii. **87.1**.
1049. Piersol, G. A. Ueber die entwicklung der embryonalen schlundspalten und ihre derivate bei säugethieren. Zeitschr. wiss. zool., xlvii, 155-189, taf. xvi-xvii. **88.1**.
1050. Rathke, H. Kiemen bei vögeln. Isis, xviii, 1100-1101. **25.1**.
1051. Reichert. Ueber die visceralbögen der wirbelthiere im allgemeinen und deren metamorphosen bei den vögeln und säugethieren. Müller's Arch., 120-222, taf. vii-ix. **37.1**.
1052. Rückert. Vorläufige mittheilungen zur entwicklung der visceralbögen bei säugethieren. Ges. f. morph. u. phys. München. Aerztl. intell. München, xxxi, 291; 301. **84.1**.
1053. Virchow, H. Ueber die spritzlochkieme der selachier. Verh. phys. ges. Berlin, 7 p. **89.1**.
1054. ——— Ueber die spritzlochkieme von Acipenser und ihre verbindung mit den kopfgefässen. Verh. phys. ges. Berlin, no. 18, 2-8. **90.1**.

GLANDS.

1055. Flemming, W. Ueber bau und eintheilung der drüsen. Arch. f. anat. u. phys., anat. abth., 287-303, taf. xviii. **88.1**.
1056. Müller, Johannes. De glandularum secernentium structura penitiori earumque prima formatione in homine atque animalibus. Lipsiae, 131 p., 17 pls. fol. **30.3**.

GROWTH.

1057. Boll, Fr. Das princip des wachsthums; eine anatomische untersuchung. Berlin, i, 82 p., 1 pl. **76.1.**
1058. Bouillet. Valeur relative des différents moyens propres à déterminer l'âge de la vie intrautérine au moment de la naissance. Record méd. Montpellier, x, 101-115. **88.1.**
1059. Brandt, E. Das alter die grössen und gewichtsbestimmungen der foetalorgane beim menschlichen foetus. München, 30 p. (Inaug. diss.) **86.1.**
1060. Fehlung, H. Die stirnfontanelle und der horizontalumfang des schädels in ihrer bedeutung für das alter und die entwicklung der frucht. Arch. f. gynäk., vii, 507-530. **75.1.**
1061. Hennig, C. Die wachsthumsverhältnisse der frucht und ihrer wichtigsten organe in den verschiedenen monaten der tragzeit. Arch. f. gynäk., xiv, 314-318. **79.1.**
1062. Mackness, G. O. C. On the relative weights of the placenta and child. Edinb. med. journ., xxxiv, 716-724. **90.1.**
1063. Minot, C. S. Growth as a function of cells. Preliminary notice of certain laws of histological differentiation. Proc. Bost. soc. nat. hist., xx, 190-201; 202-209. **79.22, 23.**
1064. ——— Researches on growth and death. Proc. soc. of arts M. I. T., 50-56. **84.64.**
1065. Nussbaum, M. Fortgesetzte untersuchungen über spontane und künstliche theilung der lebenden substanz. Sitzb. niederrh. ges. nat. u. heilk. Bonn, med. sect., 18 mai. **85.1.**
1066. ——— Ueber die theilbarkeit der lebendigen materie; i. Die spontane und künstliche theilung der infusorien. Arch. f. mikr. anat., xxvi, 485-538, taf. xviii-xxi. **86.1.**
1067. ——— Ueber die theilbarkeit der lebendigen materie; ii. Beiträge zur naturgeschichte des genus Hydra. Arch. f. mikr. anat., xxix, 265-366, taf. xiii-xx. **87.1.**
1068. Zentler, M. Des rapports du poids du foetus au poids du placenta. Paris, 37 p. 4to. **91.1.**

HAIRS.

1069. Bonnet, R. Studien über die innervation der haarbälge der hausthiere. Morph. jahrb., iv, 329-398, taf. xvii-xix. **78.1.**
1070. ——— Haarspiralen und haarspindeln. Morph. jahrb., xi, 220-228, taf. xiii. **86.2.**
1071. Duval, Mathias. Note pour servir à l'étude de quelques papillae vasculaires (vaisseaux des poils; substance médullaire des poils). Journ. de l'anat., ix, 30-41, pls. i-ii. **73.1.**
1072. Garciar, A. Beiträge zur kenntnis des haarwechsels bei menschlichen embryonen und neugeborenen. Schwalbe's Morph. arb. Jena. 136-206, pls. iv. **91.1.**
1073. Giovannini, Sebastiano. Sullo sviluppo normale e sopra alcune alterazioni dei peli umani. Bull. accad. med. Roma, xiii, 460. **87.1.**
1074. Goette, A. Zur morphologie der haare. Arch. f. mikr. anat., iv, 273-322, taf. xix-xx. **68.1.**
1075. Landois, L. Das plötzliche ergrauen der haupthaare. Virchow's Arch., xxxv, 575-599, taf. xvi. **66.1.**
1076. Langer, Carl. Ueber den haarwechsel bei thieren und menschen. Denkschr. Wien. akad. math-cl., i, 1-8. **50.1.**
1077. Ryder, J. A. On the first and second set of hair-germs developed in the skin of foetal cats. Proc. acad. nat. sc Philadelphia, 56-60. **87.2.**

HEAD.

1078. Ayers, Howard. Concerning vertebrate cephalo-genesis. Journ. morph., iv, 221-245. **90.1.**
1079. Dohrn, Anton. Bemerkungen über den neuesten versuch einer lösung des wirbeltierkopf-problems. Anat. anz., v, 53-64; 78-85. **90.1.**
1080. ——— Studien zur urgeschichte des wirbeltierkörpers; xv. Neue grundlage zur beurteilung der metamerie des kopfes. Mitth. zool. stat. Neapel, ix, 330-434, taf. xiv-xv. **90.2.**
1081. Hermann, E. G. Note on the measurements of the foetal head. Edinb. med. journ., xxvi, 451-452. **90.1.**
1082. Norris, H. W. Recent studies of the vertebrate head. Am. nat., xxv, 95-102; 334-342. **91.1.**
1083. Platt, Julia B. Further contributions to the morphology of the vertebrate head. Anat. anz., vi, 251-265. **91.1.**
1084. ——— A contribution to the morphology of the vertebrate head based on a study of Acanthias vulgaris. Journ. morph., v, 79-112. **91.2.**
1085. Reichert, K. B. Vergleichende entwickelungsgeschichte des kopfes der nackten amphibien nebst den bildungsgesetzen des wirbelthierkopfes im allgemeinen und seinen hauptsächlichsten variationen durch die einzelnen wirbelthier-klassen. Königsberg, xii, 275 p., 3 pls. 4to. **38.1.**
1086. Wijhe, J. W. van. Die kopfregion der cranioten beim Amphioxus, nebst bemerkungen über die wirbeltheorie des schädels. Anat. anz., iv, 558-566. **89.2.**

HEAD KIDNEY.

1087. Balfour, F. M. On the nature of the organ in adult teleosteans and ganoids, which is usually regarded as the head kidney or pronephros. Q. J. M. S., xxii, 12-16. **82.1.**

1088. Balfour, F. M., *and* Sedgwick, A. On the existence of a rudimentary head kidney in the embryo chick. Proc. roy. soc. Lond., xxvii, 443-446. **78.1.**

1089. ——— On the existence of a head kidney in the embryo chick and on certain points in the development of the Müllerian duct. Q. J. M. S., 1-20, pls. i-ii. **79.1.**

1090. Brook, Geo. Note on the epiblastic origin of the segmental duct in teleostean fishes and in birds. Proc. roy. soc. Edinb., 368-370. **87.1.**

1091. Calderwood, W. L. The head-kidney of teleostean fishes. Journ. mar. biol. assoc. United Kingdom, ii, 43-46, pl. v. **91.1.**

1092. Felix, W. Zur entwickelungsgeschichte der vorniere des hühnchens. Anat. anz., v, 526-530. **90.1.**

1093. Field, H. H. The development of the pronephros and segmental duct in Amphibia. Bull. mus. comp. zool., xxi, 201-340, pl. i-viii. **91.1.**

1094. Giles, A. E. Development of the fat-bodies in the frog; a contribution to the history of the pronephros. Q. J. M. S., xxix, 133-142, pl. xiv. Stud. biol. lab. Owen's coll., ii, 123-131, pl. ix (1890). **88.1.**

1095. Laguesse, E. Sur le développement du mésenchyme et du pronéphros chez les selaciens (Acanthias). C. R. soc. biol. Paris, sér. 9, iii, 861-863. **91.2.**

1096. Marshall, A. M., *and* Bles, Ed. J. The development of the kidneys and fat-bodies in the frog. Stud. biol. lab. Owen's coll., ii, 133-158, pl. x. **90.1.**

1097. Mollier, S. Ueber die entstehung des vornierensystem bei amphibien. Arch. f. anat. u. phys., anat. abth., 209-235, taf. xi-xii. **90.1.**

1098. Wijhe, J. W. van. Die betheiligung des ectoderms an der entwickelung des vornierenganges. Zool. anz., ix, 633-635. **86.1.**

HEART.

1099. Afanasieff. Zur embryonalen entwicklungsgeschichte des herzens. Bull. acad. St. Pét., xiii, 321-335, taf. i. **69.1.**

1100. Arnold, J. Ein beitrag zur normalen und pathologischen entwicklungsgeschichte der vorhofsscheidewand des herzens. Virchow's Arch., li, 220-275, taf. i. **70.1.**

1101. Aubert, H. Beiträge zur entwicklungsgeschichte der fische; ii. Die entwicklung des herzens und des blutes im hechteie. Zeitschr. wiss. zool., vii, 345-364, taf. xviii. **56.1.**

1102. Bernays. Entwicklungsgeschichte der atrioventrikularklappen. Morph. jahrb., ii, 478-518, taf. xxxii-xxxiii. **76.1.**

1103. Blaschek, A. Untersuchung über herz, pericard, endocard und pericardialhöhle. Mitth. embryol. inst. univ. Wien, 33-50. **85.1.**

1104. Born, G. Ueber die bildung der klappen, ostien und scheidewände im säugetierherzen. Anat. anz., iii, 606-612. **88.1.**

1105. ——— Beiträge zur entwicklungsgeschichte des säugetierherzens. Arch. f. mikr. anat., xxxiii, 284-378, taf. xix-xxii. **89.1.**

1106. Budin, *and* Chaignot. Recherches sur les battements du coeur du foetus. Gaz. méd. Paris, 199 p. **79.1.**

1107. Dareste, C. Mémoire sur la dualité primitive du coeur dans l'évolution du poulet. Journ. de l'anat. et phys., 249-266. **77.1.**

1108. Fano, G. Étude physiologique des premiers stades de développement du coeur embryonnaire du poulet. Arch. ital. biol., xiii, 387-422. **90.1.**

1109. Gasser, E. Ueber die entstehung des herzens bei vogelembryonen. Arch. f. mikr. anat., xiv, 459-470, taf. xxvi-xxvii. **77.3.** Abstract: Sitzb. Marburg ges., 1876, 37-42.

1110. Gerlach, L. Ueber die lebenszähigkeit des embryonalen herzens von warmblütern. Sitzb phys.-med. soc. Erlangen, 84-91. **86.2.**

1111. Gibson, G. A. The thickness of the walls of the heart during foetal life (prelim. notice). Verh. X. intern. med. kongress Berlin, ii, anat. abth., 144. **91.1.**

1112. Handyside, P. D. On traces in the adult heart of its transitions in form during foetal life. Proc. roy. soc. Edinb., vi, 499-501, pl. i. **69.1.**

1113. Hoffmann, C. K. Ueber die entstehung der endothelialen anlage des herzens und der gefässe bei hai-embryonen (Acanthias vulgaris). Anat. anz., vii, 270-273. **92.1.**

1114. Junglön, H. Ueber die anlage des herzens bei Lacerta agilis. Anat. anz., iv, 288. **89.1.**

1115. Lindes, G. Ein beitrag zur entwicklungsgeschichte des herzens. Dorpat, 59 p., 2 pls. 4to. (Diss.) **65.1.**

1116. Masius, Jean. Quelques notes sur le développement du coeur chez le poulet. Arch. de biol., ix, 403-417, pl. xxix. **89.2.**

1117. Mayer, Paul. Ueber die entwicklung des herzens und der grossen gefässstämme bei den selachiern. Mitth. zool. stat. Neapel, vii, 338-370, pls. xi-xii. **87.1.**

1118. Oellacher, J. Ueber die erste entwicklung des herzens und der pericardial- oder herzhöhle bei Bufo cinereus. Arch. f. mikr. anat., vii, 157-165, taf. xvi. **71.1.**

1119. Rabl, C. Ueber die bildung des herzens der amphibien. Morph. jahrb., xii, 252-274, taf. xv-xvi. **86.1.**

1120. Röse, Carl. Beiträge zur entwicklungsgeschichte des herzens. Heidelberg, 19 p., 1 pl. 4to. (Inang. diss.) **88.1.**

1121. Röse, Carl. Zur entwicklungsgeschichte des säugethierherzens. Morph. jahrb., xv, 436-456, taf. xvi. **89.1.**
1122. Schenk, S. L. Ueber die entwicklung des herzens und der pleuroperitonealhöhle in der herzgegend. Sitzb. Wien. akad., liv, 469-472. **66.1.**
1123. ——— Zur physiologie des embryonalen herzens. Sitzb. Wien. akad., lvi, 111-115. **67.1.**
1124. Schimkewitsch, W. Ueber die identität der herzbildung bei den wirbel- und wirbellosen thieren; Noch etwas über die identität der herzbildung bei den metazoen. Zool. anz., viii, 37-40; 384-386. **85.1.**
1125. Schmidt, F. F. Bidrag til kundskaben om hjertets udviklingshistorie. Nord. med. ark. Stockholm, ii, no. 23, 1-47, taf. i. **70.1.**
1126. Schwink, F. Ueber die entwickelung des herzendothels der amphibien. Anat. anz., v, 207-213. **90.1.**
1127. Strahl, H., *and* Carius, F. Beiträge zur entwickelungsgeschichte des herzens und der körperhöhlen. Arch. f. anat. u. phys., anat. abth., 231-248, taf. xv. **89.1.**

HEREDITY.

1128. Bambeke, Charles van. Pourquoi nous ressemblons à nos parents. Bull. acad. Belg., sér. 3, x, 901-944. **85.1.**
1129. Bemmelen, J. F. van. Die erblichkeit erworbener eigenschaften. Biol. centralbl., x, 641-652; 686-694. **90.1.**
1130. Cohen, H. M. Das gesetz der befruchtung und vererbung begründet auf die physiologische bedeutung der ovula und spermatozoen für ärtze und naturwissenschaftlich-gebildete thierzüchter. Nördlingen, 47 p. **75.1.**
1131. Darin, Charles. Vererbung. Kosmos, ix, 458-459. **81.1.**
1132. Frenzel, Johannes. Das idioplasma und die kernsubstanz. Arch. f. mikr. anat., xxvii, 73-128. **86.5.**
1133. Gray, J. P. Heredity. Am. journ. insanity, xl, 1-21. **84.1.**
1134. Hensen, V. Die grundlagen der vererbung nach dem gegenwärtigen wissenskreis. Landwirth. jahrb., xiv, 731 767, taf. viii-ix. **85.1.**
1135. Kölliker, A. Die bedeutung der zellenkerne für die vorgänge der vererbung. Zeitschr. wiss. zool., xlii, 1-46. **85.1.**
1136. ——— Das karyoplasma und die vererbung: eine kritik der Weismann'schen theorie von der kontinuität des keimplasmas. Zeitschr. wiss. zool., xliv, 228-238. **86.3.**
1137. Kollmann, J. Vererbung erworbener eigenschaften. Biol. centralbl., vii, 531-534. **87.1.**
1138. ——— [Review of] Weismann's "Ueber die bedeutung der geschlechtlichen fortpflanzung für die selektionstheorie," [and] Virchow's "Ueber akklimatisation." Biol. centralbl., v, 673-679; 705-710. **86.1.**
1139. McCrady, J. A provisional theory of generation. Proc. Bost. soc. nat. hist., xix, 171-185. **78.1.**
1140. McKendrich, J. G. On the modern cell theory and theories as to the physiological basis of heredity. Proc phil. soc. Glasgow, xix, 1-55. **88.1.**
1141. Minot, C. S. The physical basis of heredity. Science, viii, 125-130. **86.85.**
1142. Nägeli, C. v. Mechanisch-physiologische theorie der abstammungslehre. Münehen. 8vo. Abstract: Biol. centralbl., iv, 488-499; 517-528. **84.1.**
1143. Nussbaum, M. Ueber die veränderungen der geschlechtsproducte bis zur eifurchung; ein beitrag zur lehre der vererbung. Arch. f. mikr. anat., xxiii, 155-213, taf. ix-xi. **84.2.**
1144. Osborn, H. F. The paleontological evidence for the transmission of acquired characters. Am. nat., xxiii, 561-566. **89.1.**
1145. Richarz, Fr. Ueber zeugung und vererbung. Bonn, 46 p. 8vo. **80.1.**
1146. Thomson, J. A. The history and theory of heredity. Proc. roy. soc. Edinb., xvi, 91-116. **89.1.**
1147. Virchow, R. Descendenz und pathologie. Arch. f. path. anat., ciii, 1-14; 205-215; 413-436. **86.1.**
1148. Waldeyer, W. Ueber die karyokinese und ihre bedeutung für die vererbung. Deutsch. med. wochenschr., xiii, 925-927. **87.3.**
1149. Weigert, C. Neuere vererbungstheorien. Schmidt's Jahrb. ges. med., ccxv, 89-104. **87.1.**
1150. Weismann, A. Ueber die vererbung. Jena, 59 p. 8vo. **83.1.**
1151. ——— Die continuität des keimplasma's als grundlage einer theorie der vererbung. Jena, 122 p. 8vo. **85.1.**
1152. ——— Prof. Weismann's theory of heredity. Nature, xli, 317-323. **90.1.**
1153. ——— Bemerkungen zu einigen tages-problemen. Biol. centralbl., x, 11-12; 33-44. **90.2.**

HUMAN EMBRYOS.

1154. Ahlfeld, Fr. Beschreibung eines sehr kleinen menschlichen eies. Arch. f. gynäk., xiii, 241-248, taf. vii. **78.1.**
1155. Baudouin, Marcel. Les recherches d'embryologie humaine en France. Progrès méd., sér. 2, viii, 492-494. **88.1.**
1156. Beigel. Der drittkleinste bisher bekannte menschliche embryo. Arch. f. gynäk., xiii, 437-439, taf. xiii. **78.1.**
1157. Beigel, *and* Löwe. Beschreibung eines menschlichen eichens aus der zweiten bis dritten woche der schwangerschaft. Arch. f. gynäk., xii, 421-432, taf. viii. **77.1.**
1158. Breus, Karl. Ueber ein menschliches ei aus der zweiten woche der gravidität. Wien. med. wochenschr., 502-504. **77.1.**
1158a. Bruch, C. Untersuchungen über die entwickelung der thierischen gewebe; v. Ueber die entwickelung der gewebe beim menschen, vi, 247-310. Abh. Senckenb. naturf. ges., iv, 261-460, taf. i-vi; vi, 185-310, taf. xxxvii-xliii (vii-xii). **67.1.**

1159. Chiarugi, G. Di un uovo umano del principio della seconda settimana e degli inviluppi materni del medessimo. Boll. soc. cult. sc. med. Siena, v, 139-157, pl. i. **87.1.**
1160. ——— Anatomia di un embrione umano della lunghezza di mm. 2.6 in linea retta. Atti soc. tosc. sc. nat. Pisa, x, 66-94, tav. v-vi. **88.1.**
1161. Ecker, A. Kleine embryologische mittheilungen. Ber. verh. naturf. ges. Freiburg i. B., vi, 116-120, taf. v. **73.1.**
1162. ——— Beiträge zur kenntniss der äusseren formen jüngster menschlicher embryonen. Arch. f. anat. u. phys., anat. abth., 403-406, taf. xxiva. **80.1.**
1163. ——— Besitzt der menschliche embryo einen schwanz? Arch. f. anat. u. phys., anat. abth., 421-430, taf. xxiii-xxiv. **80.2.**
1164. ——— Replik und compromissätze. Arch. f. anat. u. phys., anat. abth., 441-442. **80.3.**
1165. Fol, H. Sur l'anatomie d'un embryon humain de la quatrième semaine. C. R. acad. sc. Paris, xcvii, 1563-1566. **83.2.**
1166. ——— L'anatomie d'un embryon humain d'un peu plus de trois semaines. Rev. méd. suisse romande, iv, 177-202, pls. i-ii. **84.1.**
1167. ——— Description d'un embryon humain de cinq millimètres et six dixièmes. Rec. zool. suisse, i, 357-401, pl. xvi-xx. **84.2.**
168. Giacomini, C. Sur quelques anomalies de développement de l'embryon humain. Arch. ital. biol., ix, 359-381, pl. i-ii. **88.1.**
1169. ——— Su alcune anomalie di sviluppo dell' embrione umano. Atti accad. sc. Torino, xxiii, 148-157, tav. i-ii. **88.2.**
1170. ——— Su alcune anomalie di sviluppo dell' embrione umano. Atti accad. sc. Torino, xxiv, 576-600, tav. viii. **89.2.**
1171. Omitted.
1172. Halpryn, P. Mittheilungen über die präparationsergebnisse einer frühzeitigen menschlichen frucht. Mitth. embryol. inst. univ. Wien, i, 235-254, taf. xxii-xxiv. **80.1.**
1173. Hennig, C. Ueber eines der jüngsten menschlichen eier und über fortbestand der allantois. Arch. f. gynäk., v, 169-173, taf. ix. **73.1.**
1174. His, W. Zur kritik jüngerer menschlicher embryonen. Arch. f. anat. u. phys., anat. abth., 407-420. **80.2.**
1175. ——— Mittheilungen zur embryologie der säugethiere und des menschen. His's Arch., 303-329. taf. xi-xii. **81.1.**
1176. ——— Die anfänge unseres körperlichen daseins. Schweiz. corr. bl., xiv, 337-348. **84.1.**
1177. Omitted.
1178. Janosik, J. Zwei junge menschliche embryonen. Arch. f. mikr. anat., xxx, 559-595, taf. xxxiv-xxxv. **87.1.**
1179. Keibel, Franz. Ein sehr junges menschliches ei. Arch. f. anat. u. phys., anat. abth., 250-267, taf xiv. **90.1.**
1180. ——— Ueber den schwanz des menschlichen embryos. Anat. anz., vi, 670-675. **91.3.**
1181. ——— Ein menschlicher embryo mit scheinbar bläschenförmiger allantois. Arch. f. anat. u. phys., anat. abth., 352-355, taf. xix-xx. **91.4.**
1182. Kieser, D. G. Der ursprung des darmkanals aus der vesicula umbilicalis dargestellt im menschlichen embryo. Göttingen, 31 p., 2 pls. 4to. **10.1.**
1183. Kölliker, A. Der W. Krause'sche menschliche embryo mit einer allantois; ein schreiben an Herrn Prof. His. Arch. f. anat. u. phys., anat. abth., 109-110. **82.2.**
1184. ——— Einige beobachtungen über die organe junger menschlicher embryonen. Sitzb. phys.-med. ges. Würzburg, 85-86. **83.2.**
1185. Kollmann, J. Beiträge zu der entwicklungsgeschichte des menschen. Zeitschr. f. biol., iv, 260-296, taf. vii. **68.1.**
1186. ——— Die menschlichen eier von 6 mm. grösse. Arch. f. anat. u. phys., anat. abth., 275-311, taf. xii-xiii. **79.1.**
1187. ——— Die körperform menschlicher normaler und pathologischer embryonen. Arch. f. anat. u. phys., anat. abth., 105-138, taf. v. **89.1.**
1188. Krause, W. Ueber einen frühzeitigen menschlichen embryo. Zool. anz., iii, 283-284. **80.1.**
1189. ——— Ueber zwei frühzeitige menschliche embryonen. Zeitschr. wiss. zool., xxxv, 130-140, taf. ix. **81.3.**
1190. Kyburg, W. B. Beschreibung von föten und peripheren eitheilen einer vierlingsgeburt nebst musterung der angaben über die geschlechtsverhältnisse der einem ei entstammenden föten. Halle a. S., 27 p., 1 pl. 4to. (Diss.) **87.1.**
1191. Mall, F. A human embryo twenty-six days old. Journ. morph., v, 459-480, pls. xxix-xxx. **91.3.**
1192. Müller, Johannes. Zergliederungen menschlicher embryonen aus früherer zeit der entwickelung. Meckel's Arch., 411-434, taf. xi, fig. 11-13. **30.2.**
1193. ——— [Brief description of a human ovum of 7-8 lines diameter.] Müller's Arch., 28. Cf. Müller's Arch., 1836, p. clxvii, Müller's Physiol., 1840, bd. ii, 713-714. **34.1.**
1194. Phisalix, C. Sur l'anatomie d'un embryon humain de trente-deux jours. C. R. acad. sc. Paris, civ, 799-802. **87.1.**
1195. ——— Étude d'un embryon humain de 10 millimètres. Arch. zool. expér., sér. 2, vi, 279-351, pls. xiii-xviii. **88.1.**

1196. Phisalix, C. Contribution à la pathologie de l'embryon humain. Journ. de l'anat. et phys., xxvi, 217-235, pls. viii. **90.1.**

1197. Preuschen, Franz von. Vorläufige mittheilung über die ergebnisse der anatomischen untersuchung eines frischen menschlichen embryo mit freier blasenförmiger allantois 3.7 mm. lange. Greifswald, 14 p., 1 pl. 4to. **82.1.**

1198. Reichert, C. B. Beschreibung einer frühzeitigen menschlichen frucht im bläschenförmigen bildungszustande, nebst vergleichenden untersuchungen über die bläschenförmigen früchte der säugethiere und des menschen. Abh. akad. wiss. Berlin, 92 p., taf. i-v. **73.1.**

1199. Remy, Ch. Observation d'un embryon humain long d'un centimètre. Robin's Journ. anat., 556-565, pl. xxi. **80.1.**

1200. Romiti, G. Nota su un novo umano mostruoso. Atti soc. tosc. sc. nat. Pisa, vi, 170-179. **88.1.**

1201. Schlesinger, W. Menschliches ei aus sehr früher zeit der schwangerschaft. Wien. med. bl., xi, 780; Intern. klin. rundschau, ii, 982-983. **88.1.**

1202. Schwabe, C. G. Beschreibung einer sehr frühzeitigen menschlichen frucht im bläschenförmigen bildungszustande. Berlin, 29 p., 8vo. (Diss.) **78.1.**

1203. Schwabe, G. Eine frühzeitige menschliche frucht, etc. Zeitschr. f. geburt. u. gynäk., iv, 196. **79.1.**

1204. Seiler, D. Burchard Wilhelm. Die gebärmutter und das ei des menschen in den ersten schwangerschaftmonaten. Dresden, 38 p., 12 pls. fol. **32.1.**

1205. Soemmerring, S. T. Icones embryonum humanorum. Francof. ad Moenum, 10 p., 2 pls. fol. **1799.1.**

1206. Spee, F., Graf von. Ueber einen menschlichen embryo von 2.69 mm. längstem geraden durchmesser. Mitth. ver. Schl.-Holst. ärtze, heft 11, st. 8, 174. **88.2.**

1206a. ——— Beobachtungen an einer menschlichen keimscheibe mit offener medullarrinne und canalis neurentericus. Arch. f. anat. u. phys., anat. abth., 159-176, taf. xi. **89.1.**

1207. Thompson, Allen. Contributions to the history of the structure of the human ovum and embryo before the third week after conception with a description of some early ova. Edinb. med. surg. journ., lii, 119-136, pl. ii. **39.1.**

1208. Toldt, C. Ueber die altersbestimmung menschlichen embryonen. Prag. med. wochenschr., iv, 121. **79.1.**

1209. Waldeyer, W. Anatomische untersuchung eines menschlichen embryo von 28-30 tagen. Stud. phys. inst. Breslau, heft 3, 55-70, pl. i. **65.1.**

1210. Zimmermann. Reconstructionen eines menschlichen embryos von 7 mm. länge aus der 4 woche. Verh. anat. ges., iii, 139-142. **89.2.**

HYBRIDS.

1211. Born, G. Ueber die inneren vorgänge bei der bastard-befruchtung der froscheier. Bresl. ärztl. zeitschr., h. 16. **84.1.**

1212. ——— Weitere beiträge zur bastardirung zwischen den einheimischen anuren. Arch. f. mikr. anat., xxvii, 192-271, taf. x-xii. **86.1.**

1213. Pflüger, E. Die bastardzeugung bei den batrachiern. Pflüger's Arch., xxix, 48-75, taf. i. **83.5.**

HYPOPHYSIS.

1214. Albrecht, P. Ueber existenz oder nichtexistenz der Rathke'schen tasche. Biol. centralbl., v, 724-726. **85 1.**

1215. Jägerskiold, M. L. Note sur le développement du corps pituitaire chez la couleuvre. Verh. biol. ver. Stockholm, ii, 92-95, 1 pl. **91.1.**

1216. Kranshaar, R. Entwicklung der hypophysis und epiphysis bei nagethieren. Zeitschr. wiss. zool., xli, 79-98, taf. v. **85.1.**

1217. Mihalkowics, V. von. Ueber die entwicklung des hirnanhanges und das vordere ende der chorda. Centralbl. f. med. wiss., xii, 307-308. **74.1.**

1218. ——— Wirbelsaite und hirnanhang. Arch. f. mikr. anat., xi, 389-441, taf. xxii. **75.1.**

1219. Müller, W. Ueber entwicklung und bau der hypophysis und des processus infundibuli cerebri. Jen. zeitschr. f. med. u. naturw., vi, 354-425, taf. ix-xii. **71.4.**

1220. ——— Die hypobranchialrinne der tunikaten und deren vorhandensein bei Amphioxus und den cyklostomen. Jen. zeitschr. f. med. u. naturw., vii, 327-332. **73.1.**

1221. Rathke, H. Ueber die entstehung der glandula pituitaria. Müller's Arch., 482-485. **38.1.**

1222. Scott, W. B. On the development of the pituitary in Petromyzon and the significance of that organ in other types. Science, ii, 184-186. **83.2.**

IMPREGNATION.

1223. Beneden, Ed. van. La maturation de l'oeuf, la fécondation et les premières phases du développement embryonnaire des mammifères; communication préliminaire. Bull. acad. Belg., xl, 686-736. **75.1.**

1224. ——— Recherches sur la maturation de l'oeuf et la fécondation (Ascaris megalocephala). Arch. de biol., iv, 265-640, pl. x-xix. **83.1.**

1225. ——— Sur la fécondation chez l'ascaride mégalocéphale. Anat. anz., iii, 104. **88.1.**

1226. Beneden, E. van. Kopulation der geschlechtsprodukte, die reifung des eies, der befruchtungsvorgang und die mitose bei Ascaris megalocephala. Anat. anz., iii, 707-714. **88.2.**

1227. Beneden, E. van, *and* Julin, Charles. Observations sur la maturation, la fécondation et la segmentation de l'oeuf chez les cheiroptères. Arch. de biol., i, 551-571, pls. xxii-xxiii; Abstract: Bull. acad. Belg., xlix. **80.1.**

1228. Beneden, E. van, *and* Neyt, A. Nouvelles recherches sur la fécondation et la division mitosique chez l'ascaride mégalocéphale. Bull. acad. Belg., xiv, 215-295, pls. i-vi. **87.1.**

1229. Bischoff, Th. L. W. Bemerkung über den ort der befruchtung der säugethiereiern. Zeitschr. rat. med., xxiii, 268-270. **65.1.**

1230. ——— Geschichtliche bemerkungen zu der lehre von der befruchtung und der ersten entwicklung des säugethiereies. Wien. med. wochenschr., xxxiii, 319-322. **73.1.**

1231. Blanchard, R. La fécondation dans la série animale. (Revue bibliographique.) Journ. de l'anat. et phys., xiv, 551-562; 701-762. **78.1.**

1232. Böhm, A. A. Ueber die befruchtung des neunaugeneies. Sitzb. math.-phys. kl. bayer. akad. wiss. München, 53-62. **87.1.**

1233. ——— Ueber reifung und befruchtung des eies von Petromyzon planeri. Arch. f. mikr. anat., xxxii, 613-670, pls. xxiv-xxv. **88.1.**

1234. ——— Die befruchtung des forelleneies. München. med. wochenschr., xxxviii, 539-542. **91.1.**

1235. Boveri, Theodor. Zellenstudien. Jen. zeitschr. f. naturw., xxii, 685-882, taf. xix-xxiii. **88.1.**

1236. ——— Uber partielle befruchtung. München. med. wochenschr., xxxv, 570-572; 613. **88.2.**

1237. ——— Zellenstudien. Uber das verhalten der chromatischen kernsubstanz bei der bildung der richtungskörper und der befruchtung. Jen. zeitschr. f. naturw., xxiv, 314-401, taf. xi-xiii. **90.1.**

1238. Calberla, E. Der befruchtungsvorgang beim ei von Petromyzon planeri. Zeitschr. wiss. zool., xxx, 437-487, taf. xxvii-xxix. **78.1.**

1239. Dewitz, J. Ueber die vereinigung der spermatozoen mit dem ei. Pflüger's Arch., xxxvii, 219-223. **85.1.**

1240. ——— Ueber gesetzmässigkeit in der ortsveränderung der spermatozoen und in der vereinigung derselben mit dem ei. Arch. f. ges. phys., xxxviii, 358-385, taf. iv. **86.1.**

1241. Eberth, C. J. Die befruchtung des thierischen eies nach untersuchungen am echinidenei. Fortschr. d. med., ii, 469-472. **84.1.**

1242. Fol, H. Sur le commencement de l'hénogénie chez divers animaux. Arch. zool. expér., vi, 145-169. **77.1.**

1243. ——— Recherches sur la fécondation et le commencement de l'hénogénie chez divers animaux. Mém. soc. phys. hist. nat. Genève, xxvi, 89-394, pls. i-vii. **78.1.**

1244. Guiguard, Léon. Sur le mode d'union des noyaux sexuels dans l'acte de la fécondation. C. R. acad. sc. Paris, cx, 726-728. **90.2.**

1245. Hancock, J. L. Triple fertilization in egg of domestic fowl. Am. nat., xxv, 1030. **91.1.**

1246. Hensen, V. Ueber eine züchtung unbefruchteter eier. Centralbl. f. med. wiss., vii, 403-404. **69.2.**

1247. Hertwig, O. Beiträge zur kenntniss der bildung, befruchtung und theilung des thierischen eies. Morph. jahrb., i, 347-434, taf. x-xiii. **75.1.**

1248. ——— Weitere beiträge zur kenntniss der bildung, befruchtung und theilung des thierischen eies. Morph. jahrb., iii, 271-279. **77.1.**

1249. ——— Beiträge zur kenntniss der bildung, befruchtung und theilung des thierischen eies. Morph. jahrb., iii, 1-86, taf. i-v. **77.2.**

1250. ——— Beiträge zur kenntniss der bildung, befruchtung und theilung des thierischen eies. Morph. jahrb., iv, 156-175, taf. vi-viii; 179-213, taf. ix-xi. **78.1.**

1251. ——— Das problem der befruchtung und der isotropie des eies, eine theorie der vererbung. Jen. zeitschr. f. naturw., xviii, 276-318. Reprint: Untersuch. morph. phys. der zelle, h. 3. **85.1.**

1252. ——— Vergleich der ei- und samenbildung bei nematoden; eine grundlage für celluläre streitfragen. Arch. f. mikr. anat., xxxvi, 1-138, taf. i-iv. **90.1.**

1253. ——— Experimentelle studien am tierischen ei vor, während und nach der befruchtung. Jen. zeitschr. f. naturw., xxiv, 268-313, taf. viii-x. **90.2.**

1254. Hertwig, O. *and* R. Experimentelle untersuchungen über die bedingungen der bastardbefruchtung. Jen. zeitschr. f. naturw., xix, 121-165. **85.1.**

1255. ——— Ueber den befruchtung und teilungsvorgang des tierischen eies unter dem einfluss äusserer agentien. (Untersuchungen zur morphologie und physiologie der zelle, heft v.) Jena, 156 p., 7 pls. **87.1.**

1256. Hertwig, R. Ueber die gleichwertigkeit der geschlechtskerne (von ei- und samenkern) bei den seeigeln. München. med. wochenschr., xxxv, 907-909. **88.1.**

1257. ——— Ueber kernstruktur und ihre bedeutung für zellteilung und befruchtung. Sitzb. ges. f. morph. phys., München, iv, 83-87. **88.2.**

1258. Hoffmann, C. K. Het standpunt onzer heden doagsche kennis over het wezen der bevruchting. Nederl. tijdschr. geneesk. Amsterdam, r. 2, xviii, 142-155. **82.1.**

1259. Jordan, E. O. The spermatophores of Diemyctylus. Journ. morph., v, 263-270. **91.1.**

1260. Keber, G. A. F. De spermatozoorum introitu in ovula. Königsberg, ix, 118 p., 4 pls. 4to. **53.1.**
1261. Kultschitzky, N. Die befruchtungsvorgänge bei Ascaris megalocephala. Arch. f. mikr. anat., xxxi, 567-593, taf. xxix-xxx. **88.1.**
1262. ——— Ueber die eireifung und die befruchtungsvorgänge bei Ascaris marginata. Arch. f. mikr. anat., xxxii, 671-687, taf. xxvi-xxvii. **88.2.**
1263. Kupffer, C. Ueber active betheiligung des dotters am befruchtungsacte bei Bufo variabilis und vulgaris. Sitzb. München. akad., xii, 608-618. **82.1.**
1264. Loewe, L. Ueber befruchtung. Berlin. klin. wochenschr., 505-508. **78.2.**
1265. Mark, E. L. Maturation, fecundation and segmentation of Limax campestris Binney. Bull. mus. comp. zool., vi, 173-625, pls. i-v. **81.1.**
1266. Massart, Jean. Sur la pénétration des spermatozoides dans l'oeuf de la grenouille. Bull. acad. Belg., sér 3, xviii, 215-220. **89.1.**
1267. Mondino, C., *and* Sala, L. Osservazionl sulla maturazione e sulla fecondazione delle ova. Arch. sc. med. Torino, xiv, 9-28, taf. i-ii. **90.1**
1268. Müller, A. Ueber die befruchtungserscheinungen im ei der neunaugen. Schrift. phys.-ökon. ges. Königsberg, l, 109-119, taf. iv. **64.1.**
1269. Newport. On the impregnation of the ovum in the Amphibia. Phil. trans. roy. soc. Lond., 169-242, pl. xiv. **51.1.**
1270. Nijhoff, G. C. Der ort der befruchtung. Gynäk. centralbl., ix, 401-403. **85.1.**
1271. Oppel, A. Die befruchtung des reptilieneies. Anat. anz., vi, 536-544. **91.1.**
1272. ——— Die befruchtung des reptilieneies. Arch. f. mikr. anat., xxxix, 215-290, taf. ix-xii. **92.1.**
1273. Pflüger, E. Wirkt der saft der hoden nichtbrünstiger männchen befruchtend? Pflüger's Arch., xxix, 44-48. **83.4.**
1274. Platner, G. Ueber die befruchtung bei Arion empiricorum. Arch. f. mikr. anat., xxvii, 32-72, taf. v-vi. **86.1.**
1275. Ransom, W. H. On the impregnation of the ovum in the stickleback. Proc. roy. soc. Lond., vii, 168-172. **54.1.**
1276. Rein, G. Beiträge zur kenntniss der reifungserscheinungen und befruchtungsvorgänge am säugethierei. Arch. f. mikr. anat., xxii, 233-270, taf. ix. **83.1.**
1277. Rückert, J. Ueber die befruchtung bei elasmobranchiern. Verh. anat. ges., v, 253-254. **91.1.**
1278. ——— Ueber physiologische polyspermie bei meroblastischen wirbeltiereiern. Anat. anz., vii, 320-333. **92.3.**
1279. ——— Zur befruchtung des selachiereies. Anat. anz., vi, 308-322. **91.2.**
1280. Rusconi. Ueber künstliche befruchtung von fischen und über einige neue versuche in betreff künstlicher befruchtung an froschen. Müller's Arch., 185-193, taf. v. **40.1.**
1281. Schenk. Das säugethierei künstlich befruchtet ausserhalb des mutterthieres. Mitth. embryol. inst. univ. Wien, i, 107-118. **80.1.**
1282. Schneider, A. Ueber befruchtung. Zool. anz., iii, 252-257. **80.1.**
1283. ——— Ueber die befruchtung der thierischen eier. Zool. anz. iii, 426-427. **80.3.**
1284. ——— Das ei und seine befruchtung. Breslau, 88 p., 10 pls. 4to. **83.1.**
1285. ——— Nachträgliche bemerkungen über "Das ei und seine befruchtung." Zool. beitr., i, 127-139, taf. xix, fig. 4-16. **84.1.**
1286. Schultze, O. Ueber reifung und befruchtung des amphibieneies. Anat. anz., i, 149-152. **86.1.**
1287. ——— Untersuchungen über die reifung und befruchtung des amphibieneies. Zeitschr. wiss. zool., xlv, 177-226, taf. xi-xiii. **87.1.**
1288. Selenka, E. Zur befruchtung des thierischen eies. Biol. centralbl., v, 8-10. **85.1.**
1289. Tafani, A. La fécondation et la segmentation étudiées dans les oeufs des rats. Arch. ital. biol., xi, 112-117 **89.1.**
1290. Waldeyer, W. Ueber karyokinese und ihre beziehungen zu den befruchtungsvorgängen. (For translation see no. 459.) Arch. f. mikr. anat., xxxii, 1-122. **88.1.**
1291. Weismann, A., *and* Ischikawa, C. Nachtrag zu der notiz über partielle befruchtung. Ber. naturf. ges. Freiburg i. B., iv, 55-58. **88.1.**
1292. ——— Ueber die befruchtungserscheinungen bei den dauereiern von daphniden. Biol. centralbl., viii, 430-436. **88.2.**
1293. ——— Ueber partielle befruchtung. Ber. naturf. ges. Freiburg i. B., iv, 51-53. **88.3.**
1294. ——— Ueber die paracopulation im daphnideneie sowie über reifung und befruchtung desselben. Zool. jahrb., iv, 155-196, taf. vii-xiii. **89.1.**
1295. Whitman, C. O. The kinetic phenomena of the egg during maturation and fecundation (oökinesis). Journ. morph., i, 227-252. **87.3.**
1296. ——— Spermatophores as a means of hypodermic impregnation. Journ. morph., iv, 361-406, pl. xiv. **91.3.**
1297. Windle, B. C. A. On some recent researches in connection with the maturation, fertilisation and segmentation of the ovum. Proc. Birmingham phil. soc., vi, 243-264. **89.1.**
1298. Zacharias, O. Neue untersuchungen über die copulation der geschlechtsprodukte und den befruchtungsvorgang bei Ascaris megalocephala. Arch. f. mikr. anat., xxx, 111-182, taf. viii-x. **87.1**
1299. ——— Ueber partielle befruchtung. Biol. centralbl., viii, 368. **88.1.**

INTESTINE.

1300. Barth. Beitrag zur entwicklung der darmwand. Sitzb. Wien. akad., lviii, abth. 2, 129-136, taf. i. **68.1.**
1301. Bizzozero, G. Ueber die regeneration der elemente der schlauchförmigen drüsen und des epithels des magendarmkanals. Anat. anz., iii, 781-784. **88.1.**
1302. ——— Sulla derivazione dell' epitelio dell' intestino dall' epitelio delle sue ghiandole tubulari. Atti accad. Torino, xxiv, 702. **89.2.**
1303. Bizzozero, G., *and* Vasale, G. Ueber den verbrauch der drüsenzellen der säugetiere in erwachsenen drüsen. Centralbl. med. wiss., xxiii, 49-51. **85.1.**
1304. Campana. Essai d'une détermination, par l'embryologie comparative, des parties analogues de l'intestin chez les vertébrés supérieurs. C. R. acad. sc. Paris, lxxvii, 217-220. **73.1.**
1305. Dareste, C. Nouvelles recherches sur la production artificielle de l'inversion des viscères. C. R. acad. sc. Paris, lxx, 761-763. **70.1.**
1306. Davidoff, M. v. Untersuchungen über die beziehungen des darmepithels zum lymphoiden gewebe. Arch. f. mikr. anat., xxix, 495-525, taf. xxx-xxxi. **87.1.**
1307. Demon, F. Développement de la portion sousdiaphragmatique du tube digestif. Lille, 126 p., 4 pls. 8vo. (Thèse.) **83.1.**
1308. Haidenhain. Beiträge zur histologie und physiologie der dünndarmschleimhaut. Pflüger's Arch., xliii, suppl., 103 p., 4 taf. **88.1.**
1309. Houssay, F. La métamérie de l'endoderme et du système circulatoire primitif dans la région post-branchiale du corps des vertébrés. C. R. acad. sc. Paris, cxii, 959-961. C. R. soc. biol., iii, 278-280. **91.2.**
1310. Howes, G. B. On the visceral anatomy of the Australian torpedo (Hypnos subnigrum) with especial reference to the suspension of the vertebrate alimentary canal. Proc. zool. soc., Lond., 669-675, pl. lvii. **90.3.**
1311. Langer, C. von. Ueber das verhalten der darmschleimhaut an der iliocoecal-klappe, nebst bemerkungen über ihre entwicklung. Denkschr. math.-naturw. cl. Wien. akad., liv, 51-58, taf. i-ii. **87.1.**
1312. Loudon, B. Die elemente des darmdrüsenblattes in ihren ersten veränderungen. Mitth. embryol. inst. univ. Wien, ii, 187-194. **83.1.**
1313. Patzelt, V. Ueber die entwickelung der dickdarmschleimhaut. Sitzb. Wien. akad., lxxxvi, abth. 3, 145-172, taf. i-iii. **83.1.**
1314. Retterer, Ed. Origine et développement des plaques de Peyer chez le lapin et le cobaye. C. R. soc. biol. Paris, sér. 9, iii, 871-873. **91.3.**
1315. Rüdinger. Ueber die umbildung der Lieberkühn'schen drüsen durch die follikel im wurmfortsatze des menschen. Verh. anat. ges., v, 65-68. **91.1.**
1316. Schroeder. Ueber die divertikel-bildungen am darmkanale. Augsburg, 27 p., 2 pls. 4to. **54.1.**
1317. Stoss. Vergleichend-anatomische untersuchungen über die entwicklung des verdauungskanals der wiederkäuer. Deutsch. zeitschr. f. thiermed, xvi, 96-124, 52 figs. **90.1.**
1318. Strahl, H. Zur bildung der cloake des kaninchenembryo. Arch. f. anat. u. phys., anat. abth., 156-168, taf. iv. **86.2.**
1319. Tourneux, F. Note sur l'intestin caudal chez l'embryon du chat. C. R. soc. biol. Paris, sér. 9, ii, 97-100. **90.2.**

INVERTEBRATES.

1320. Balfour, F. M. The anatomy and development of Peripatus capensis. Q. J. M. S., xxiii, 213-259, pls. xiii-xx. **83.1.**
1321. Hatschek, Berthold. Beiträge zur entwicklungsgeschichte der lepidopteren. Jen. zeitschr. f. naturw., xi, 115-148, taf. i-iii. Naumburg a. S., 38 p. (Inaug. diss.) **77.2.**
1322. ——— Studien über entwickelungsgeschichte der anneliden; ein beitrag zur morphologie der bilaterien. Arb. zool. inst. univ. Wien, i, 277-404, taf. i-viii. **78.1.**
1323. ——— Ueber entwicklungsgeschichte von Teredo. Arb. zool. inst. univ. Wien, iii, 1-44, taf. i-iii. **80.1.**
1324. ——— Ueber entwicklung von Sipunculus nudus. Arb. zool. inst. univ. Wien, v, 61-140, taf. i-vi. **83.1.**
1325. ——— Zur entwicklung des kopfes von Polygordius. Arb. zool. inst. univ. Wien, vi, 109-120, taf. i. **85.1.**
1326. ——— Entwickelung der trocophora von Eupomatus uncinatus Philippi (Serpula uncinata). Arb. zool. inst. univ. Wien, vi, 121-148, taf. i-v. **85.2.**
1327. Henchman, Annie. The origin and development of the nervous system in Limax maximus. Bull. mus. comp. zool., xx, 169-208, pls. i-x. **90.1.**
1328. Kleinenberg, N. Hydra; eine anatomisch-entwicklungsgeschichtliche untersuchung. Leipzig, vi, 90 p., 4 pls. 4to. **72.1.**
1329. ——— The development of the earthworm, Lumbricus trapezoides Dugès. Q. J. M. S., xix, 206-244, pls. ix-xi. **79.1.**
1330. ——— De l'origine du système nerveux central des annélides. Arch. ital. biol., i, 63-77. **83.1.**
1331. Kölliker, A. Beiträge zur entwicklungsgeschichte wirbelloser thiere. Müller's Arch., 68-141, taf. vi-vii. **43.1.**
1332. ——— Entwicklungsgeschichte der cephalopoden. Zürich, 180 p., 6 pls. 8vo. **44.1.**

1333. Korschelt. Ueber die bildungsweise des mittleren keimblattes bei den echinodermen. Sitzb. ges. naturf. freunde Berlin, 56-57. **89.1.**

1333a. Kowalevsky, A. Embryologische studien an würmen und arthropoden. Mém. acad. St. Pét., sér. 7, xvi, no. 12, 70 p., 12 pls. **71.1.**

1334. Lankester, E. R. Contributions to the developmental history of the Mollusca. Phil. trans. roy. soc. Lond., clxv, i-48, pls. i-xii. **75.1.**

1335. ——— Notes on embryology and classification. Q. J. M. S., xvii, 399-454, pl. xxv. **77.1.**

1336. ——— The vertebration of the tail of Appendicolariae. Q. J. M. S., xxii, 387-390. **82.1.**

1337. ——— On the coincidence of the blastopore and anus in Paludina vivipara. Q. J. M. S., xvi, 377-385, pl. xxv. **76.1.**

1338. Metschnikoff, E. Vergleichend-embryologische studien; 3. Ueber die gastrula einiger metazoen (Echinus). Zeitschr. wiss. zool., xxxvii, 286-313, taf. xix-xx. **82.1.**

1339. Patten, Wm. The embryology of Patella. Arb. zool. inst. univ. Wien, vi, 149-174, taf. xiv-xvii. **85.1.**

1340. Rabl, C. Die ontogenie der süsswasser pulmonaten. Jen. zeitschr. f. naturw., ix, 195-240, taf. vii-ix. **75.1.**

1341. ——— Ueber die entwicklungsgeschichte der malermuschel. Jen. zeitschr. f. naturw., x, 310-393, taf. x-xii. **76.1.**

1342. ——— Ueber die entwickelung der tellerschnecke. Morph. jahrb., v, 561-655, taf. xxxii-xxxviii. **79.1.**

1343. Reichenbach, Heinrich. Ueber die entwicklungsgeschichte des flusskrebses. Zeitschr. wiss. zool., xxix, 123-196; 263-266, taf. x-xi. **77.1.**

1344. Robin, Ch. Mémoire sur les phénomènes qui se passent dans l'ovule avant la segmentation du vitellus. Journ. phys., v, 67-109. **62.1.**

1345. Sedgwick, A. The development of Peripatus capensis. Proc. roy. soc. Lond., xxxviii, 354-361. **85.1.**

1346. ——— The development of Peripatus capensis, pt. i. Q. J. M. S., xxv, 449-468, pls. xxxi-xxxii. **85.2.**

1347. ——— The development of the Cape species of Peripatus, pt. ii. Q. J. M. S., xxvi, 175-212, pls. xii-xiii. **86.1.**

1348. Selenka, E. Keimblätter und organanlage bei echiniden. Zeitschr. wiss. zool., xxxiii, 39-54, taf. v-vii. **79.1.**

1349. Sheldon, Lilian. On the development of Peripatus novae zealandiae. Q. J. M. S., xxix, 283-293, pls. xxv-xxvi. **88.1.**

1350. Spengel, J. W. Beiträge zur kenntniss der gephyreen, i. Mitth. zool. stat. Neapel, i, 357-419, taf. viii-xii. **79.2.**

1351. Voeltzkow, A. P. Entwickelung im ei von Musca vomitoria. Arb. zool.-zoot. inst. Würzburg, ix, 1-48, taf. i-iv. **89.1.**

1352. ——— Melolontha vulgaris; ein beitrag zur entwickelung im ei bei insecten. Arb. zool.-zoot. inst. Würzburg, ix, 49-64, taf. v. **89.2.**

1353. Whitman, C. O. The embryology of Clepsine. Q. J. M. S., xviii, 215-315, pls. xii-xv. **78.2.**

1354. ——— The germ-layers of Clepsine. Zool. anz., ix, 171-176. **86.2.**

1355. ——— A contribution to the history of the germ-layers in Clepsine. Journ. morph., i, 105-179, pl. iv-vi. **87.2.**

1356. Wilson, E. B. The germ-bands of Lumbricus. Journ. morph., i, 183-192, pl.vii. **87.1.**

JOINTS.

1356a. Bernays, A. Die entwickelung des kniegelenks des menschen. Morph. jahrb., iv, 403-446, taf. xxi. **78.1.**

1357. Hepburn, D. The development of diarthrodial joints in birds and mammals. Journ. anat. phys., xxiii, 507-522, pl. xxii. **89.1.**

1358. Tillmanns, H. Zur histologie der synovialmembranen. Langenbeck's Arch. f. klin. chir., xix, 693-711. **76.1.**

KIDNEY.

1359. Emery, C. Recherches embryologiques sur le rein des mammifères. Arch. ital. biol., iv, 80-92, taf. i. **83.1.**

1360. ——— Ricerche embriologiche sul rene dei mammiferi. Mem. accad. linc. tav., xv, 12 p., 1. **83.2.**

1361. Golgi, C. Annotazioni intorno all' istologia dei reni dell' uomo e di altri mammiferi e sull' istogenesi dei canalicoli oriniferi. Rend. accad. linc. Roma, v, sem. 1, 334-342. **89.1.**

1362. Hamburger, O. Ueber die entwicklung der säugethierniere. Arch. f. anat. u. phys., anat. abth., suppl., 15-51, taf. iii-iv. **90.1.**

1363. Kallay, A. Die niere im frühen stadium des embryonallebens. Mitth. embryol. inst. univ. Wien, 51-57, taf. i. **85.1.**

1364. Krukenberg. Zur frage der fötalen nierensecretion und der fruchtwasserbildung. Arch. f. gynäk., xxvi, 258-272. **85.1.**

1365. Lieberkühn, N. Ueber die allantois und die nieren von säugethierembryonen. Sitzb. Marburg. ges., 1-11. **76.1.**

1366. Löwe, L. Zur entwicklungsgeschichte der säugethierniere. Arch. f. mikr. anat., xvi, 507-532, taf. xxiv. **79.2.**

1367. Riedel, B. Entwicklung der säugethierniere. Unters. anat. inst. Rostock, 38-72, taf. i. **74 1.**

1368. Schweigger-Seidel, F. Die nieren des menschen und der säugethiere in ihrem feineren baue. Halle, 88 p., 4 pls. 8vo. **65.2.**

1369. Sedgwick, A. Development of the kidney in its relation to the Wolffian body in the chick. Q. J. M. S., n. s. xx, 146-166, pls. xvii-xviii. **80.1.**

1370. Thayssen, Adolf. Die entwicklung der nieren. Centralbl. f. med. wiss., xi, 593-594. **73.1**.
1371. Toldt, C. Untersuchungen über das wachsthum der nieren des menschen und der säugethiere. Sitzb. Wien. akad., lxix, abth. 3, 123-150, 1 taf. **74.1**.
1372. Viéron, D. M. M. Recherches sur le développement et l'histogenèse du rein chez l'homme. Bordeaux, 48 p., 2 pls. 4to. **87.1**.

LARYNX.

1373. Fauvel. Quelques points de l'embryogénie du larynx. Gaz. d. hôp., 52; 107. **79.1**.
1374. Ganghofner, F. Beiträge zur entwicklungsgeschichte des kehlkopfes. Zeitschr. f. heilk., i, 187-206, taf. v-vi. **80.1**.
1375. Ketel, H. Beiträge zur entwickelungsgeschichte und anatomie der pharynx. Hasse's Anat. stud., i, 14-20, taf. ii-iii. **70.1**.
1376. Putelli, F. Ueber einige verklebungen im gebiete des kehlkopfes des embryos. Med. jahrb. Wien, lxxxiv, 323-328; Mitth. embryol. inst. univ. Wien, 74-79. **88.1**.
1377. Roth, W. Der kehldeckel und die stimmritze im embryo nebst einigen bemerkungen über die entwicklung der schleimdrüsen. Mitth. embryol. inst. univ. Wien, i, 145-162, taf. x-xi. **80.1**.
1378. Strazza, G. Zur lehre über die entwickelung der kehlkopfmuskeln. Med. jahrb. Wien, 105-116, pls. i-iii. **88.1**.

LEUCOCYTES.

1378a. Maggi, L. Sull' importanza dei fagociti nella morfologia dei metazoi. Rend. Ist. Lomb. Milano, ser. 2, xxi, 357-365. **88.1**.

LIMBS.

1379. Balfour, F. M. On the development of the skeleton of the paired fins of Elasmobranchii considered in relation to its bearings on the nature of the limbs of the Vertebrata. Proc. zool. soc. Lond., 656-671, pls. lvii-lviii. **81.1**.
1380. Bardeleben, K. Hand und fuss. Tagebl. 59 vers. naturf. artze Berlin, 96-102. **87.1**.
1381. Baur, G. Beiträge zur morphogenie des carpus und tarsus der vertebraten; theil 1. Batrachia. Jena, 86 p., 3 pls. 8vo. **88.3**.
1382. Davidoff, M. v. Beiträge zur vergleichenden anatomie der hinteren gliedmasse der fische, i. Morph. jahrb., v, 450-520, taf. xxviii-xxxi. **79.1**.
1383. Debierre, Ch. Le développement des membres du coté droit l'importe-t-il originairement sur celui des membres du coté gauche? Bull. soc. anthr. Lyon, vi, 148-164. **87.1**.
1384. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; ix. Die unpaare flosse in ihrer bedeutung für die beurtheilung der genealogischen stellung der tunicaten und des Amphioxus, und die reste der beckenflosse bei Petromyzon; x. Zur phylogenese des wirbelthierauges. Mitth. zool. stat. Neapel, vi, 399-480, taf. xxiii-xxiv. **86.2**.
1385. Emery, C. Ueber die beziehungen des cheiropterygiums zum ichthyopterygium. Zool. anz., x 185-189. **87.1**.
1386. ——— Zur morphologie des hand- und fussskeletes. Anat. anz., v, 283-294 **90.1**.
1387. Flower, W. H. On the correspondence between the anterior and posterior extremity, and the modifications of the position of the limbs in the higher Vertebrata. Rep. Brit. assoc. adv. sc. London, (1871) xl, 137. **70.1**.
1388. Gegenbaur, C. Ueber das skelet der gliedmaassen der wirbelthiere im allgemeinen und der hintergliedmaassen der selachier insbesondere. Jen. zeitschr. f. naturw., v, 397-447, taf. xv-xvi. **70.1**.
1389. ——— Ueber das archipterygium. Jen. zeitschr. f. naturw., vii, 131-141, taf. x. **73.2**.
1390. ——— Zur morphologie der gliedmaassen der wirbelthiere. Morph. jahrb., ii, 396-420. **76.1**.
1391. Götte, A. Ueber entwicklung und regeneration des gliedmassenskelets der Molche. Leipzig, 47 p., 5 pls. **79.2**.
1392. Hanover, A. Primordialbrusken og dens forbening i truncus og extremiteter hos mennesket för födselen. Vidensk. selsk. skr. Kjöbenhavn, raekke 6, naturvid.-math. afd., iv, 267-314. **87.1**.[1]
1393. Hatschek, B. Die paarigen extremitäten der wirbeltiere. Verh. anat. ges. Berlin, iii, 82-90. **89.1**.
1394. Holl, M. Sull' omodinamia delle cinture scapolare e pelvica. Monit. zool. ital., ii, 123-135. **91.1**.
1395. Howes, G. B. On the skeleton and affinities of the paired fins of Ceratodus, with observations upon those of the Elasmobranchii. Proc. zool. soc. Lond., 3-26, pls. i-iii. **87.1**.
1396. Johnson, Alice. On the development of the pelvic girdle and skeleton of the hind limb in the chick. Q. J. M. S., xxiii, 399-411, pls. xxvi-xxvii. **83.1**.
1397. Kastschenko, N. Ueber die entwicklung der finger beim menschlichen embryo. (Russian.) Charkow, 14 st., taf. i. **84.1**.
1398. Kollmann, J. Handskelett und hyperdaktylie. Mitth. anat. inst. Vesal. Basel, 604-634, taf. viii. **89.2**.
1399. Lebouecq, H. L'apophyse styloïde du 3ème métacarpien chez l'homme. Ann. soc. méd. Gand. **87.1**.
1400. Mivart, St. George. Notes on the fins of elasmobranchs with considerations on the nature and homologies of vertebrate limbs. Trans. zool. soc. Lond., x, 439-484, pls. lxxiv-lxxix. **79.1**.

1401. Nagel, W. Die entwicklung der extremitäten der säugethiere. Marburg, 41 p., 1 pl. 8vo. (Diss.) **78.1**.
1402. Parker, R. W., *and* Robinson, H. B. Inherited congenital deformity of hands and feet. Lancet, i, 729-730. **87.1**.
1403. Paterson, A. M. The position of the mammalian limb; regarded in the light of its innervation and development. Journ. anat. phys., 1889, xxiii, 283-299. Stud. anat., anat. dept. Owen's coll., i, 31-47. **91.2**.
1404. Prince, Edw. E. The development and morphology of the pectoral fins in teleostean fishes. Glasgow, 24 p., 2 pls. 4to. (Inaug. diss.) **90.1**.
1405. Rosenberg, A. Ueber die entwicklung des extremitäten-skeletes bei einigen durch reduction ihrer gliedmassen characterisirten wirbelthieren. Zeitschr. wiss. zool., xxiii, 116-166, taf. v-vii. **73.1**.
1406. Ryder, J. A. On the homologies and early history of the limbs of vertebrates. Proc. acad. nat. sc. Philadelphia, 344-368. **87.4**.
1407. Sabatier, A. Anatomie comparée; comparaison des ceintures et des membres antérieurs et postérieurs dans la série des vertébrés. Montpellier, 457 p., 9 pls. 4to. **80.1**.
1408. Strasser, H. Zur entwicklung der extremitätenknorpel bei salamandern und tritonen; theil 1. Entwicklung des knorpelgewebes; theil 2. Die entwicklung und gliederung des knorpelskeletes. Morph. jahrb., v, 240-315, taf. xvi-xix. **79.1**.
1409. Thacher, J. K. Median and paired fins, a contribution to the history of the vertebrate limbs. Trans. Connecticut acad., iii, 281-310, pl. xlix-lx. **77.1**.
1410. Thompson, W. D'Arcy. On the hind limb of Ichthyosaurus and on the morphology of the vertebrate limbs. Journ. anat. phys., xx, 532-535. **86.1**.
1411. Tornier, G. Ueber den säugetier-praehallux; ein dritter beitrag zur phylogenese des säugetierfusses. Arch. f. naturgesch., jahrg. 57, bd. i, 113-204, taf. vii. **91.1**.
1412. Wiedersheim, R. Die ältesten formen des carpus und tarsus der heutigen amphibien. Morph. jahrb., ii, 421-434, taf. xxix. Nachträgl. bemerkungen, *ibid.*, iii, 152-154. **76.1**.
1413. ——— Zur urgeschichte des beckens. Ber. naturf. ges. Freiburg, iv, 109-112. **89.2**.
1414. ——— Mitteilungen über die entwicklungsgeschichte des schulter- und beckengürtels. Anat. anz., v, 13-26. **90.1**.

LIVER.

1415. Shore, T. W. Notes on the origin of the liver. Journ. anat. phys., xxv, 166-197, pl. iv. **91.1**.
1416. Toldt, C., *and* Zuckerkandl, E. Ueber die form- und textur-veräuderungen der menschlichen leber während des wachsthums. Sitzb. Wien. akad., lxxii, abth. 3, 241-295, taf. i-ii. **76,1**.
1417. Wertheimer, E. Développement du foie et du système porte abdominal. Lille, 98 p., 1 pl. 4to. (Thèse.) **83.1**.

LUNGS AND TRACHEA.

1418. His, W. Zur bildungsgeschichte der lungen beim menschlichen embryo. Arch. f. anat. u. phys., anat. abth., 89, 106, taf. vii-viii. **87.3**.
1419. La Croix, Nicolai Jalan de. Die entwickelung des lungenepithels beim menschlichen fötus und der einfluss der athmung auf dasselbe. Arch. f. mikr. anat., xxii, 93-131, taf. ii. **83.1**.
1420. Miller, W. S. The lobules of the lung and its blood-vessels. Anat. anz., vii, 181-190. **92.1**.
1421. Philip, R. W. Beiträge zur lehre über die entwicklung der trachea. Mitth. embryol. inst. univ. Wien, ii, 177-185. **83.1**.
1422. Rathke, H. Ueber die entwickelung der athemwerkzeuge bei den vögeln und säugethieren. Nova acta leop.-carol. akad. Bonn, xiv, 159-216. **28.1**.
1423. Robinson, A. Observations on the earlier stages in the development of the lungs of rats and mice. Journ. anat. phys., 1889, xxiii, 224-241, pl. xii. Stud. anat., anat. dept. Owen's coll., i, 49-66, pl. i. **91.1**.
1424. Selenka, E. Beitrag zur entwicklungsgeschichte der luftsäcke des huhns. Zeitschr. wiss. zool., xvi, 178-182, taf. viii. **66.2**.
1425. Stieda, L. Einiges über bau und entwicklung der säugethierlungen. Zeitschr. wiss. zool., xxx, suppl., 106-122, taf. vi. **78.1**.
1426. Uskow, N. Bemerkungen zur entwicklungsgeschichte der leber und der lungen. Arch. f. mikr. anat., xxii, 219-227, taf. vii-viii. **83.2**.
1427. Willach, P. Beiträge zur entwicklung der lunge bei säugethieren. Osterwieck, Zickfeldt, 23 p. 8vo. **88.1**.

LYMPHATICS.

1428. Budge, A. Ueber das dem zweiten blutkreislaufe entsprechende lymphgefäss-system bei hühnerembryonen. Centralbl. f. med. wiss., xix, 625-626. **81.2**.
1429. ——— Untersuchungen über die entwickelung des lymphsystems beim hühnerembryo. Arch. f. anat. u. phys., anat. abth., 59-88, taf. v-vi. **87.1**.

1430. Chievitz, J. H. Zur anatomie einiger lymphdrüsen im erwachsenen und fötalen zustande. Arch. f. anat. u. phys. anat. abth., 347-370, taf. xiv-xv. **81.1.**
1431. Flemming, W. Studien über regeneration der gewebe; i. Die zellvermehrung in den lymphdrüsen und verwandten organen, und ihr einfluss auf deren bau Arch. f. mikr. anat., xxiv, 50-91, taf. iv. **85.2.**
1432. ———— Schlussbemerkungen über die zellvermehrung in den lymphoiden drüsen. Arch. f. mikr. anat., xxiv, 355-361. **85.3.**
1433. Sertoli, Enrico. Ueber die entwickelung der lymphdrüsen. Sitzb. Wien. akad., liv, 149-162, taf. i-ii. **66.1.**
1434. Zwaardemacker. Oorsprung der lymphcellen. Nederl. tijdschr. geneesk. Amsterdam. R. 2, xxiii, 387-393. **87.1.**

MAMMAE.

1435. Creighton, Ch. On the development of the mamma and the mammary function. Journ. anat. phys., xi, 1-32, pl. i. **77.1.**
1436. Curtis, F. Le développement de la mamelle et du mamelon d'après les travaux les plus récents. Rev. biol. du nord France, i, 441-457; ii, 1-17. **89.1.**
1437. Gegenbaur, C. Zur kenntniss der mammarorgane der monotremen. Leipzig, 39 p., 1 pl. 4to. **36.1.**
1438. ———— Bemerkungen über die milchdrüsenpapillen der säugethiere. Jen. zeitschr. f. naturw., vii, 204-217. **73.1.**
1439. ———— Zur genaueren kenntniss der zitzen der säugethiere. Morph. jahrb., i, 266-281, taf. viii. **75.1.**
1440. Huss, M. Beiträge zur entwicklungsgeschichte der milchdrüsen beim menschen und bei wiederkäuern. Jen. zeitschr. f. naturw., vii, 176-203, taf. xii-xiii. **73.1.**
1441. Klaatsch, H. Zur morphologie der saugethier-zitzen. Morph. jahrb., ix, 233-324, taf. xiii-xvii. **84.1.**
1442. Langer, C. Ueber den bau und die entwicklung der milchdrüsen bei beiden geschlechtern. Denkschr. Wien. akad., iii, abth. 2, 25-38, taf. v-vii. **52.1.**
1443. Rauber, A. Ueber den ursprung der milch und die ernährung der frucht im allgemeinen. Leipzig, 48 p., 2 pls. 8vo. **79.3.**
1444. Rein, G. Untersuchungen über die embryonale entwicklungsgeschichte der milchdrüse, i. Arch. f. mikr. anat., xx, 431-501, taf. xxviii-xxix. **82.1.**
1445. ———— Untersuchungen über die embryonale entwicklungsgeschichte der milchdrüse, ii. Arch. f. mikr. anat., xxi, 678-694, taf. xxx. **82.2.**
1446. Ribbert. Ueber die regeneration der mammilla nebst bemerkungen über ihre entwicklung. Arch. f. mikr. anat., xxxvii, 139-158, taf. ix. **91.1.**
1447. Ryder, J. A. On the development of the mammary glands and genitalia of the Cetacea. Bull. U. S. fish comm., v, 135-142. **85.4.**
1448. Scanzoni. Ueber die milchsecretion und die entzündlichen anschwellungen der brustdrüsen bei neugeboren. Verh. phys.-med. ges. Würzburg, ii, 300-303. **52.1.**
1449. Schultze, O. Ueber die erste anlage des milchdrüsenapparates. Anat. anz., vii, 265-270. **92.1.**
1450. Sinéty, de. Recherches sur la mamelle des enfants nouveaux-nés. Arch. de phys., vii, 291-302, pls. xiv-xv. **75.1.**

MAMMALS.

1451. Bambeke, Ch. van. Onderzoekingen over de ontwikkelingsgeschiedenis van den egel (Erinaceus europaeus). Bull. acad. Belg., sér. 3, xiv, 893-915. **87.1.**
1452. Beneden, Ed. van. La maturation de l'oeuf, la fécondation et les premières phases du développement embryonnaire des mammifères, d'après des recherches faites chez le lapin. Journ. zool., v, 10-56. **76.1.**
1453. ———— Untersuchungen über die blätterbildung, den chordakanal und die gastrulation bei den säugetieren. Anat. anz., iii, 709-714. **88.3.**
1454. Biehringer, Joachim. Ueber die umkehrung der keimblätter bei der scheermaus (Arvicola amphibius Desm.). Arch. f. anat. u. phys., anat. abth., 279-286, taf. xvii. **88.1.**
1455. ———— Ueber die umkehrung der keimblätter bei den nagethieren. Biol. centralbl., x, 403-414. **91.1.**
1456. Bischoff, Th. L. W. Entwickelungsgeschichte des kaninchencies. Braunschweig, x, 154 p., 16 pls. 4to. **42.1.**
1457. ———— Entwicklungsgeschichte mit besondere berücksichtigung der missbildungen. R. Wagner's Handwörterb. d. phys., i, 860-928. **42 2.**
1458. ———— Entwicklungsgeschichte des hunde-eies. Braunschweig, 134 p., 15 pls. 4to. **45.1.**
1459. ———— Entwicklungsgeschichte des meerschweinchens. Giessen, 56 p., 8 pls. 4to. **52.1.**
1460. ———— Entwicklungsgeschichte der rehcies. Giessen, 36 p., 8 pls. 4to. **54.1.**
1461. ———— Ueber die ranzzeit des fuchses und die erste entwicklung seines eies. Sitzb. akad. wiss. München, ii, 44-55. **63.2.**
1462. ———— Neue beobachtungen zur entwicklungsgeschichte des meerschweinchens. Abh. math.-phys. cl. bayer. akad. München, x, 115-166, taf. vii-x. **70.1.**
1463. ———— Ueber die lebenszähigkeit des foetus der warm-blüter. Pflüger's Arch., xv, 50-51. **77.1.**

1464. Bischoff, Th. L. W. Historisch-kritische bemerkungen zu den neuesten mittheilungen über die erste entwicklung der 'säugethiereier. München, 93 p., 8vo. **77.2.**

1465. Bojanus, L. Observatio anatomica de fetu canino 24 dierum ejusque velamentis. Nova acta leop.-carol. akad. Bonn, x, 141-152, pl. viii. **21.1.**

1466. Bonnet, R. Zur embryologie der wiederkäuer. Mitth. morph.-phys. ges. München. Aerztl. intell.-bl. München, xxx, 526. **83.1.**

1467. ———— Beiträge zur embryologie der wiederkäuer, gewonnen am schafei. Arch. f. anat. u. phys., anat. abth., 170-230. taf. ix-xi. **84.1.**

1468. ———— Ueber die entwicklung der allantois und die bildung des afters bei den wiederkäuern und über die bedeutung der primitivrinne und des primitivstreifs bei den embryonen der säugetiere. Anat. anz., iii, 105-126. **88.1.**

1469. ——— Präparate und zeichnungen zur entwickelungsgeschichte des schafes. Anat. anz., iii, 714-717. **88.2.**

1470. ——— Beiträge zur embryologie der wiederkäuer, gewonnen am schafei. Arch. f. anat. u. phys., anat. abth., 1-106, taf. i-vi. **89.1.**

1471. Caldwell, W. H. The embryology of Monotremata and Marsupialia, pt. i. (Abstract.) Proc. roy. soc. Lond., xlii, 177-180. **87.1.**

1472. ——— The embryology of Monotremata and Marsupialia, pt. i. Phil. trans. roy. soc. Lond., clxxviii, 463-486, pls. xxix-xxxi. **87.2.**

1473. Camerano, L. Recherches sur l'anatomie d'un foetus d'otarie (Otaria jubata Forst.). (Extrait de l'auteur.) Arch. ital. biol., ii, 285-291. **82.1.**

1474. Carius, F. Ueber den kopffortsatz des kaninchens. Sitzb. Marburg. ges., 1887, 26-28. **88.2.**

1475. ——— Ueber die ausbildung des hinteren körperendes bei Cavia. Sitzb. Marburg. ges., 87-89. **88.3.**

1476. Cohnstein, J., *and* Zuntz, N. Weitere untersuchungen zur physiologie des säugethier-fötus. Arch. phys., xlii, 342-392. **88.1.**

1477. Cruikshank, W. Experiments in which on the third day after impregnation the ova of rabbits were found in the Fallopian tubes; and on the fourth day after impregnation in the uterus itself with the first appearance of the foetus. Phil. trans. roy. soc. Lond., lxxxvii, 197-214, pl. i. Reil's Arch. f. phys., iii, 1799, 74-94, taf. i. **1797.1.**

1478. Deniker, J. Sur un foetus de gorille. C. R. acad. sc., Paris, xcviii, 753-756. **84.1.**

1479. ——— Sur un foetus de gibbon et son placenta. C. R. acad. sc., Paris, c, 654-656. **85.1.**

1480. ——— Recherches anatomiques et embryologiques sur les singes anthropoïdes; foetus de gorille et de gibbon comparés aux foetus humains et aux anthropoïdes jeunes et adultes. Arch. zool. expér., sér. 2, iii, 1-265, pls. xxii-xxx. Abstract: Nature, xxxv, 509-510. **86.2.**

1481. Edwards, A. Milne. Observations sur quelques points de l'embryologie des lémuriens et sur les affinités zoologiques de ces animaux. Ann. sc. nat., sér. 5, xv, art. 6, 7 p. **72.2.**

1482. Fraser, A. On the inversion of the blastodermic layers in the rat and mouse. Proc. roy. soc. Lond., xxxiv, 430-437. **83.1.**

1483. Fries, S. Ueber die fortpflanzung der einheimischen chiropteren. Zool. anz., ii, 355-357. **79.1.**

1484. ——— Ueber die fortpflanzung von Meles taxus. Zool. anz., iii, 486-492. **80.1.**

1485. Goette. Zur entwicklungsgeschichte des kaninchens. Centralbl. med. wiss., vii, 866-867. **69.2.**

1486. Haacke, W. Meine entdeckung des eierlegens der Echidna hystrix. Zool. anz., vii, 647-653. **84.1.**

1487. Haddon, A. C. Note on the blastodermic vesicle of mammals. Proc. roy. soc. Dublin, iv, 536-547. **86.1.**

1488. Heape, Walter. On the germinal layers and early development of the mole. Proc. roy. soc. Lond., xxxiii, 190-198. **82.1.**

1489. ——— The development of the mole (Talpa europea); the formation of the germinal layers, and early development of the medullary groove and notochord. Q. J. M. S., xxiii, 412-452, pl. xxviii-xxxi. Reprint: Stud. morph. lab. Cambridge, ii, 29-75, pl. vi-ix. **83.1.**

1490. ——— The development of the mole (Talpa europea), the ovarian ovum and the segmentation of the ovum. Q. J. M. S., xxvi, 157-174, pl. xi. Reprint: Sedgwick's Studies, ii, 201-218, pl. xxi. **86.1.**

1491. ——— The development of the mole (Talpa europea), stages E. to J. Q. J. M. S., xxvii, 123-163, pl. xi-xiii. **86.2.**

1492. ——— Preliminary note on the transplantation and growth of mammalian ova within a uterine foster mother. Proc. roy. soc. Lond., xlviii, 457-458. **90.1.**

1493. Hensen, V. Beobachtungen über die befruchtung und entwickelung des kaninchens und des meerschweinchens. Zeitschr. f. anat. u. entwick., i, 213-273; 353-423, taf. vii-xii **76.1.**

1494. ——— Bemerkungen betreffend die mittheilungen von Selenka und Kupffer über die entwickelung der mäuse. Arch. f. anat. u. phys., anat. abth., 71-75. **83.1.**

1495. ——— Ein frühes stadium des im uterus des meerschweinchens festgewachsenen eies. Arch. f. anat. u. phys. anat. abth., 61-70, taf. iii. **83.2.**

1496. Högyes, A. Beitrag zur lebenszähigkeit des säugethierfoetus. Pflüger's Arch., xv, 335-342. **77.1.**

1497. Hubrecht, A. A. W. Studies in mammalian embryology; ii. The development of the germinal layers of Sorex vulgaris. (See no. 2159). Q. J. M. S., xxxi, 499-562, pls. xxxvi-xlii. **90.1.**

1498. Jones, T. W. On the first changes in the ova of Mammifera in consequence of impregnation, and on the mode of origin of the chorion. Phil. trans. roy. soc. Lond., 339-345, pl. xvi. **37.1.**
1499. ——— On the ova of man and the Mammifera before and after fecundation. Lancet, ii, 283-284. **85.1.**
1500. Keibel, Franz. Zur entwickelungsgeschichte des igels (Erinaceus europaeus). Anat. anz., iii, 631-637. **88.1.**
1501. ——— Die entwickelungsvorgänge am hinteren ende des meerschweinchen-embryos. Arch. f. anat. u. phys., anat. abth., 407-430, taf. xxiii-xxiv. **88.2.**
1502. ——— Ueber die entwickelungsgeschichte des schweines. Anat. anz., vi, 193-198. Verh. X. intern. med. kongress Berlin, ii, anat. abth., 137-138. **91.2.**
1503. Kober, J. Studien über Talpa europaea. Verh. naturf. ges. Basel, vii, 62-119, taf. i-ii. **82.1.**
1504. Kölliker, A. Ueber die erste entwicklung des säugethier-embryo. Verh. phys.-med. ges. Würzburg, n. f. ix, 98-101. **76.1.**
1505. ——— Embryologische mittheilungen. Festschr. 100-jähr. best. naturf. ges. Halle a. S., 115-127, taf. v-vi. **79.1.**
1506. ——— Die entwicklung der keimblätter des kaninchens. Zool. anz., iii, 370-375; 390-395. **80.1.**
1507. ——— On the development of the mesoblast in the rabbit. Trans. intern. med. congr., sess. 7, i, 170-171. **81.1.**
1508. ——— Histologische und embryologische mittheilungen. Sitzb. phys.-med. ges. Würzburg, 66-72. **82.1.**
1509. Kupffer, C. Das ei von Arvicola arvalis und die vermeintliche umkehr der keimblätter an demselben. Sitzb. math.-phys. kl. akad. München., 621-637, taf. i. **82.3.**
1510. Leche, W. Zur charakteristik der extra-uterine entwickelung der beutelthiere Verh. biol. ver. Stockholm, ii, 112-116. **90.1.**
1511. Leopold, G. Die überwanderung der eier. Arch. f. gynäk., xvi, 24-44. **80.1.**
1512. Lieberkühn, N. Ueber die keimblase der säugethiere. Sitzb. Marburg. ges., 60-66. **75.1.**
1513. ——— Ueber die keimblätter der säugethiere. Fünfzigj. doctor-jubelfeier Hermann Nasse, Marburg, 26 p., 1 pl. 4to. **79.1.**
1514. ——— Zur lehre von den keimblättern der säugethiere. Sitzb. Marburg. ges., 32-41. **80.1.**
1515. Meigs, C. D. Memoir on the reproduction of the opossum (Didelphis virginiana). Trans. Am. phil. soc., x, 155-166. **53.1.**
1516. Owen, R. On the generation of marsupial animals, with a description of the impregnated uterus of the kangaroo. Phil. trans. roy. soc. Lond., 333-364, pl. vi-vii. **34.1.**
1517. ——— Exhibition of a foetal kangaroo, proving the existence of an allantois. Proc. zool. soc., v, 82-84. **37.2.**
1518. ——— Description of an impregnated uterus and of the uterine ova of Echidna hystrix. Ann. mag. nat. hist., ser. 5, xiv, 373-376, pl. xiii. **84.1.**
1519. ——— Description of a newly excluded young of the Ornithorhynchus paradoxus. (Abstract.) Proc. roy. soc. Lond., xlii. 391. **87.1.**
1520. Paladino, G. Sur les premiers phénomènes du développement de quelques mammifères. Arch. ital. biol., ii, 363-366. **82.1.**
1521. ——— Des premiers rapports entre l'embryon et l'utérus chez quelques mammifères. Arch. ital. biol., xiii, 59-70. **90.1.**
1522. Pflüger, E. Die lebenszähigkeit des menschlichen foetus. Pflüger's Arch., xiv, 628-629. **77.1.**
1523. Pouchet. Dissertation d'un foetus de cachalot. C. R. acad. sc. Paris, c, 1277-1280. **85.1.**
1524. Prévost, *and* Dumas. De la génération dans les mammifères et des premiers indices du développement de l'embryon. Ann. sc. nat., iii, 113-138, pls. v-vii. **24.1.**
1525. Rauber, Anton. Die erste entwickelung des kaninchens. Sitzb. naturf. ges. Leipzig, ii, 103-109, pl. **75.2.**
1526. Reichert, C. B. Beiträge zur entwicklungsgeschichte des meerschweinchens. Arch. f. anat., phys. u. wiss. med. Leipzig, 847-856. **60.1.**
1527. ——— Beiträge zur entwickelungsgeschichte des meerschweinchens. Phys. abh. akad. wiss. Berlin, 1861, 97-216. 8 pls. **62.1.**
1528. Repiachoff, W. Ein paar worte über die morphologische bedeutung der jüngsten säugethierkeime. Zool. anz., vi, 65-67. **83.3.**
1529. Robinson, A. Observations upon the development of the segmentation cavity, the archenteron, the germinal layers and the amnion in mammals. Q. J. M. S., xxxiii, 369-455, pls. xxiii-xxvii. **92.1.**
1530. Rudolph, K. A. Ueber den embryo der affen und einiger anderer säugethieren. Abh. akad. wiss. Berlin, i, 35-42, taf. i-iv. **28.1.**
1531. Ryder, J. A. The inversion of the germinal layers in Hesperomys. Am. nat., xxi, 863-864. **87.7.**
1532. Schäfer, E. A. Description of a mammalian ovum in an early condition of development. Proc. roy. soc. Lond., xxiv, 399-403, pl. x. **76.1.**
1533. ——— A contribution to the history of development of the guinea-pig. Journ. anat. phys., x, 772-777. **76.2.**
1534. ——— A contribution to the history of development of the guinea-pig. Journ. anat. phys., xi, 332-347, pl. x-xi. **77.1.**
1535. Selenka, E. Keimblätter und gastrulaform der maus. Biol. centralbl., ii, 550. **82.1.**

1536. Selenka, E. Zur entwickelung der affen. Sitzb. akad. wiss. Berlin, xlviii, 1257-1262. **90.2**.
1537. Spee, F. Graf. Beitrag zur entwicklungsgeschichte der früheren stadien des meerschweinchens bis zur vollendung der keimblase. Arch. f. anat. u. phys., anat. abth., 44-60, taf. ii. **83.1**.
1537a. ——— Ueber die entwickelungsvorgänge vom knoten aus in säugetierkeimscheiben. Anat. anz., iii, 314-323. **88.1**.
1538. Strahl, H. Ueber entwicklungsvorgänge am kopf und schwanz von reptilien- und säugethierembryonen. Zool. anz., vii, 376-378. **84.3**.
1539. ——— Durchschnitte der area embryonalis bei säugetierembryonen. Anat. anz., iii, 740-743. **88.2**.
1540. ——— Beiträge zur kenntniss der entwicklung von säugetierembryonen. Sitzb. Marburg. ges., 54-61. **88.3**.
1541. ——— Ueber die ausbildung des hinteren körperendes bei Cavia. Sitzb. Marburg. ges., 65-67. **88.7**.
1542. Tafani, A. I primi momenti dello sviluppo dei mammiferi; studi di morfologia normale e pathologica eseguiti sulle nova dei topi. Rend. accad. d. linc., v, sem. 1, 119-125. **89.2**.
1543. Turner, W. The forms and proportions of a foetal Indian elephant. Journ. anat. phys., xv, 519-522, pl. xxvii. **81.1**.
1544. Weil, C. Beiträge zur befruchtung und entwicklung des kaninchencies. Wien. med. jahrb., 18-29. **73.1**.

MARROW OF BONE.

1545. Bizzozero, G. Neue untersuchungen über den bau des knochenmarks bei den vögeln. Arch. f. mikr. anat., xxxv, 424-469, taf. xxvi. **90.1**.
1546. ——— Nouvelles recherches sur la structure de la moelle des os chez les oiseaux. Arch. ital. biol., xiv, 293-332, 1 pl. **91.1**.
1547. Howell, W. H. Observations upon the occurrence, structure and function of the giant cells of the marrow. Journ. morph., iv, 117-130, pl. v. **90.2**.

MARSIPOBRANCHS.

1548. Cunningham, J. T. On the reproduction and development of the conger. Journ. mar. biol. assoc. United Kingdom, ii, 16-42. **91.2**.
1549. Goette, Alex. Abhandlungen zur entwickelungsgeschichte der tiere; v. Entwickelungsgeschichte des flussneunauges (Petromyzon fluviatilis); theil 1. Hamburg und Leipzig, 95 p., 9 pls. 4to. **90.1**.
1550. Kaensche, C. C. Beiträge zur kenntniss der metamorphose des Ammocoetes branchialis in Petromyzon. Zool. beiträge, ii, 219-250, taf. xviii-xxi. **90.1**.
1551. Omitted.
1552. Kupffer, C. Die entwickelung von Petromyzon planeri. Arch. f. mikr. anat., xxxv, 469-558, taf. xxvii-xxxii. **90.1**.
1553. Müller, A. Ueber die entwicklung der neunaugen; ein vorläufiger bericht. Müller's Arch., 323-339. **56.1**.
1554. Müller, J. Vergleichende anatomie der myxinoiden und der cyklostomen mit durchbohrtem gaumen; i. Osteologie und myologie. Abh. akad. wiss. Berlin, 1-276, taf. i-ix. **35.1**.
1555. Nestler, K. Beiträge zur anatomie und entwicklungsgeschichte von Petromyzon planeri. Arch. f. naturg., jahrg. 46, bd. i, 81-112, taf. vii-viii. **90.1**.
1556. Nuel, P. J. Recherches sur le développement du Petromyzon planeri. Arch. de biol., ii, 403-454, pl. xxiv-xxv. **81.1**.
1557. Owsjannikow, Ph. Die entwicklungsgeschichte der flussneunaugen (Petromyzon fluviatilis). Bull. acad. St. Pét., xiv, 325-329. **70.1**.
1558. ——— Zur entwickelungsgeschichte des flussneunauges. Bull. acad. St. Pét., xxxiii, 83-95; Mélanges biol. tirés du bull. acad. St. Pét., xiii, 55-67. **89.1**.
1559. Schultze, Max. Die entwickelungsgeschichte von Petromyzon planeri. Naturw. verh. ges. wiss. Harlem, xii, 1-49, taf. i-viii. **56.1**.
1560. Scott, W. B. Preliminary account of the development of the lampreys. Q. J. M. S., xxi, 146-161. **81.1**.
1561. ——— Beiträge zur entwickelungsgeschichte der petromyzonten. Morph. jahrb., vii, 101-172, taf. vii-xi. **82.1**.
1562. ——— The embryology of Petromyzon. Journ. morph., i, 253-310, pls. viii-xi. **87.1**.
1563. Shipley, A. E. On some points in the development of Petromyzon fluviatilis. Q. J. M. S., xxvii, 325-370, pls. xxvi-xxix. Stud. morph. lab. Cambridge, iv, 173-218, pls. xviii-xxi. **88.1**.

MECONIUM.

1564. Baginsky, A. Das vorkommen von produkten der fäulniss im fruchtwasser und im meconium. Arch. f. anat. u. phys., phys. abth., suppl., 48-50. **83.1**.
1565. Bouillon-Lagrange. Du méconium des enfans et de celui des agneaux. Ann. de chimie, lxxxvi, 299-313; lxxxvii, 18-26. **13.1**.
1566. Förster, A. Ueber das mekonium. Wien. med. wochenschr., viii, 569. **58.1**.

1567. Fresenius, R. Ueber die nachweisung von durch meconium (kindspech) entstandenen flecken bei gerichtlich-chemischen untersuchungen. Ann. d. chemie, lxxv, 116-120. **50.1**.
1568. Huber, J. Ch. Meconium: zur forensisch-medicinischen würdigung des meconiums. Friedreich's Blätter f. gerichtl. med. Nürnb., xxxv, 24-28; 142-149. **84.1**.
1569. Lassaigne, J. L. Meconium: taches sur un drap de lit. Ann. d'hygiène, vii, 119-125. **57.1**.
1570. Senator. Das vorkommen von produkten der darmfäulniss bei neugeborenen. Zeitschr. f. physiol. chem., iv, 1-8. **80.1**.
1571. Simon, J. F. Untersuchungen des harns auf harnstoff. Arch. f. pharmac. Hanover, xxii, 35-40. **40.1**.
1572. Zweifel. Untersuchungen über das meconium. Arch. f. gynäk., vii, 474-490. **75.1**.

MENINGES.

1573. Valenti, G. Sur le développement des prolongements de la pie-mère dans les scissures cérébrales. Arch. ital. biol., xvi, 395-396. **91.2**.

MESENTERY AND OMENTUM.

1574. Lockwood, C. B. The development of the great omentum and transverse mesocolon. Journ. anat. phys., xviii, 257-264. **84.1**.
1575. Meckel, J. F. Bildungsgeschichte des darmkanales der säugethiere und namentlich des menschen. Meckel's Arch., iii, 1-84. **17.1**.
1576. Müller, J. Ueber den ursprung der netze und ihr verhältniss zum peritonealsacke beim menschen aus anatomischen untersuchungen an embryonen. Meckel's Arch., 395-411, taf. xi, figs. 1-10. **30.4**.
1577. Ranvier, L. Recherches sur la formation des mailles du grand épiploon. Arch. d. phys. norm. path. Paris, sér. 2, i, 421-428, pl. xix, figs. 4, 5, 8. **74.3**.
1578. Toldt, C. Bau und wachsthumsveränderungen der gekröse des menschlichen darmkanales. Denkschr. math.-naturw. kl. Wien. akad., xli, abth. 2, 1-56, taf. i-ii. **79.2**.
1579. ——— Die darmgekröse und netze im gesetzmässigen und im gesetzwidrigen zustand. Denkschr. math.-naturw. kl. Wien. akad., lvi, abth. 1, 1-46, pl. i-viii. **89.1**.

MENSTRUATION.

1580. Bischoff. Beiträge zur lehre von der menstruation und befruchtung. Zeitschr. f. rat. med., n. f., iv, 129-174. **54.2**.
1581. Czazan. Ovulation und menstruation. Arch. f. gynäk., xxxvi, 27-76. **89.1**.
1582. Tait, Lawson. Menstruation and the ovaries. Lancet, ii, 1044-1045. **88.1**.

MICROPYLE.

1583. André, J. Sur la préparation du micropyle dans la coque des oeufs de truite. Journ. anat. et phys., xi, 197-202. **75.1**.
1584. Bruch, C., *and* Siebold, C. Th. von. Ueber die mikropyle der fische. Zeitschr. wiss. zool., vii, 172-175, taf. ix b. **56.1**.
1585. Eigenmann, C. H. On the egg membranes and micropyle of some osseous fishes. Bull. mus. comp. zool., xix, 129-154. **90.1**.
1586. Reichert, K. B. Ueber die mikropyle der fischeier und über einen bisher unbekannten eigenthümlichen bau des nahrungsdotters reifer und befruchteter fischeier (hecht). Müller's Arch., 83-124, taf. ii-iv. **56.2**.
1587. Sehlen, D. von. Beitrag zur frage nach der mikropyle des säugethiereies. Arch. f. anat. u. phys., anat. abth., 33-51, taf. v. **82.1**.

MOUTH.

1588. Assaky. Embryologie de la bouche. Odontologie, Paris, ix, 241-249. **89.1**.
1589. Beard, J. The old mouth and the new; a study in vertebrate morphology. Anat. anz., iii, 15-23. **88.1**.
1590. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; i. Der mund der knochenfische. ii. Die entstehung und bedeutung der hypophysis bei den teleostiern. Mitth. zool. stat. Neapel, iii, 252-279, taf. xv-xix. **82.1**.
1591. His, Wilhelm. Die retromandibularbucht. Anat. anz., i, 22-25. **86.1**.
1592. Laguesse, G. J. Note sur l'origine du sinus maxillaire et de ses glandes chez l'embryon. C. R. soc. biol. Paris, sér. 8, ii, 653-654. **85.1**.
1593. Reichel, P. Beiträge zur morphologie der mundhöhlendrüsen der wirbelthiere. Morph. jahrb., viii, 1-71, taf. i. **83.1**.

MUSCLES.

1594. Aswadouroff, K. Comparaison du développement des muscles chez l'embryon humain et chez les animaux à l'état adulte. C. R. soc. biol. Paris, sér. 8, v, 677-678. **88.1.**

1595. Bardeleben, K. Ueber innervierung, entstehung und homologie der distalen gliedmassenmuskeln bei den säugetieren. Verh. anat. ges., v, 243-246. **91.2.**

1596. Barfurth, D. Die rückbildung des froschlarvenschwanzes und die sogenannten sarkoplasten. Arch. f. mikr. anat., xxix, 35-61, taf. i-ii. **87.1.**

1597. Bemmelen, J. F. v. Ueber die herkunft der extremitäten- und zungenmuskulatur bei eidechsen. Anat. anz., iv, 240-255. **89.1.**

1598. Born, G. Beiträge zur entwicklungsgeschichte der quergestreiften willkürlichen muskeln der säugethiere. Berlin, 65 p., 8vo. (Diss.) **73.1.**

1599. Bremer, L. Ueber die muskelspindeln nebst bemerkungen über structur, neubildung und innervation der quergestreiften muskelfaser. Arch. f. mikr. anat., xxii, 318-356, taf. xii-xiii. **83.1.**

1600. Bütschli, *and* Schewiakoff. Ueber den feineren bau der quergestreiften muskeln bei arthropoden. Biol. centralbl., xi, 33-39. **91.1.**

1601. Calberla, E. Studien über die entwicklung der quergestreiften muskeln der amphibien und reptilien. Arch. f. mikr. anat., xi, 442-458, taf. xxiii-xxiv. **76.1.**

1602. Cattani, Giuseppina. Cariocinesi nella fibre muscolari lisse dell' utero gravido. Gazz. d. ospit. Milano, vi, 468. **85.1.**

1603. Deiters, Otto. Beitrag zur histologie der quergestreiften muskeln. Arch. f. anat. u. phys., 393-424, taf. x. **61.1.**

1604. Dohrn, Anton. Studien zur urgeschichte des wirbelthierkörpers; xvi. Ueber die erste anlage und entwickelung der augenmuskelnerven bei selachiern und das einwandern von medullarzellen in die motorischen nerven. Mitth. zool. stat. Neapel, x, 1-40, taf. i-v. **91.1.**

1605. Eimer, G. H. Th. Die entstehung und ausbildung des muskelgewebes insbesondere der querstreifung desselben als wirkung der thätigkeit betrachtet. Zeitschr. wiss. zool., iii, suppl., 67-111. **92.1.**

1606. Felix, Walther. Theilungserscheinungen an quergestreiften muskeln menschlicher embryonen. Anat. anz., iii. 719-720. **88.1.**

1607. ——— Ueber wachsthum der quergestreiften muskulatur nach beobachtungen am menschen. Zeitschr. wiss. zool., xlviii, 224-259, taf. xv-xvi. **89.1.**

1608. Flemming, W. Ueber formen und bedeutung der organischen muskelzellen. Zeitschr. wiss. zool., xxx, suppl., 466-473, taf. xxii. **78.2.**

1609. Franque, Otto von. Beiträge zur kenutnis der muskelknospen. Verh. phys.-med. ges. Würzburg, xxiv, 19-48, taf. ii. **90.1.**

1610. Gage, Susanna P. Form, endings and relation of striated muscular fibres in the muscles of minute animals (mouse, shrew, bat and English sparrow). Microscope, viii, 225-237; 257-272, pls. viii-xii. **88.1.**

1611. Gehuchten, A. van. Étude sur la structure intime de la cellule musculaire striée. La cellule, ii, 289-453, pls. i-vi. **86.1.**

1612. ——— Étude sur la structure intime de la cellule musculaire striée. Anat. anz., ii, 792-802. **87.1.**

1613. Haswell, Wm. A. A comparative study of striated muscle. Q. J. M. S., xxx, 31-50, pls. iv-v. **89.1.**

1614. Humphry, G. M. The disposition of muscles in vertebrate animals. Journ. anat. phys., vl, (ser. 2, v), 293-376. **72.1.**

1615. Kaczander, J. Beiträge zur entwicklungsgeschichte der kaumusculatur. Mitth. embryol. inst. univ. Wien. heft i, 17-32, taf. i. **85.1.**

1616. ——— Beitrag zur lehre über die entwickelung der kaumuskeln. Anat. anz., vi, 224-227. **91.1.**

1617. Kölliker, A. Beiträge zur vergleichenden anatomie und histologie. Zeitschr. wiss. zool., ix, 138-142. **57.1.**

1618. ——— Untersuchungen über die letzten endigungen der nerven. Zeitschr. wiss. zool., xii, 149-164, taf. xiii-xvi. **62.1.**

1619. ——— Zur kenntnis der quergestreiften muskelfasern. Zeitschr. wiss. zool., xlvii, 689-710, taf. xliv-xlv. **88.4.** Prelim. notice, Sitzb. phys.-med. ges. Würzburg, xv. **88.3.**

1620. Margo, Theodor. Neue untersuchungen über die entwickelung, das wachsthum, die neubildung und den feineren bau der muskelfasern. Sitzb. Wien. akad., xxxvi, 219-240. **59.1.**

1621. Marshall, C. F. Observations on the structure and distribution of striped and unstriped muscle in the animal kingdom, and a theory of muscular contraction. Q. J. M. S., xxviii, 75-107, pl. vi. Stud. fr. biol. lab. Owens coll., ii, 1890, 73-101, pl. vi. **87.1.**

1622. ——— Further observations on the histology of striped muscle. Q. J. M. S., xxxi, 65-82, pl. xi. **90.1.**

1623. Maurer, F. Der aufbau und die entwickelung der ventralen rumpfmuskulatur bei den urodelen amphibien und deren beziehung zu den gleichen muskeln der selachier und teleostier. Morph. jahrb., xviii, 76-179, taf. iv-vi. **91.1.**

1624. Mayeda, R. Ueber die kaliberverhältnisse der quergestreiften muskelfasern. Zeitschr. f. biol., xxvii, 119-152, taf. iii-iv. **90.1.**

1625. Mayer, Sigmund. Zur histologie des quergestreiften muskels. Biol. centralbl., iv, 129-137. **84.1.**
1626. ——— Die sogenannten sarkoplasten. (Vorläuf. kritik von Margo und Paneth, Sitzb. Wien. akad., xcii, abth. 3.) Anat. anz., i, 231-235. **86.1.**
1627. McMurrich, J. P. The cranial muscles of Amia calva (L.) with a consideration of the relations of the post-occipital and hypoglossal nerves in the various vertebrate groups. Stud. biol. lab. Johns Hopkins univ., iii, 121-153, pl. x. **85.1.**
1628. Melland, B. A simplified view of the histology of the striped muscle fibre. Q. J. M. S., xxv, 371-390, pl. xxiv. A. M. Marshall's Studies from biol. lab. Owens coll., i, 225-241, pl. x. **85.1.**
1629. Mingazzini, P. Contributo alla conoscenza della fibra muscolare striata. Anat. anz., iv, 742-748. **89.1.**
1630. Navalichini. Genèse et mort des fibres musculaires chez l'animal supérieur adulte à l'état normal. Arch. slav. biol., i, 134-138. **86.1.**
1631. Paneth, Josef. Die entwicklung von quergestreiften muskelfasern aus sarkoplasten. Sitzb. Wien. akad., xcii abth. 3, 236-269, taf. i-iii. **85.1.**
1632. ——— Zur frage nach der natur der sarkoplasten. Anat. anz., ii, 136-138. **87.1.**
1633. Retzius, G. Zur kenntniss der quergestreiften muskelfaser. Biol. untersuch., i, 1-26, taf. i-ii. **81.2.**
1634. Rollett, Alex. Untersuchungen über den bau der quergestreiften muskelfasern; theil 1. Denkschr. math.-naturw. kl. Wien. akad., xlix, abth. 1, 81-132, taf. i-iv. **85.1.**
1635. ——— Untersuchungen über den bau der quergestreiften muskelfasern; theil 2. Denkschr. math.-naturw. kl. Wien. akad., li, abth. 1, 23-68, taf. i-iv. **85.2.**
1636. Roule, L. Sur le développement des fibres musculaires. C. R. acad. sc. Paris, cxii, 245-246. **91.1**
1637. Omitted.
1638. Ruge, Georg. Zur entheilung der gesichtsmuskulatur speciell des musc. orbicularis oculi. Morph. jahrb., xii, 184-192. **87.1.**
1639. ——— Untersuchungen über die gesichtsmuskulatur der primaten. Leipzig, 130 p., 8 pls. fol. **87.2.**
1640. Schäfer, E. A. On the minute structure of the muscle columns or sarcostyles which form the wing-muscles of insects. Proc. roy. soc. Lond., xlix, 280-286, pl. iv-v. **91.2.**
1641. ——— On the structure of cross striated muscles. Monatsschr. f. anat. u. phys , viii, 178-238, pl. xv-xvii. **91.3.**
1642. Schneider, A. Ueber das sarcolemma. Zool. beiträge, Breslau, ii, 212-217, taf. xvii. **88.1.**
1643. ——— Zur frühesten entwickelung besonders der muskeln der elasmobranchier. Zool. beiträge, ii, 251-267, taf. xxii. **90.1.**
1644. Schultze, Max. Ueber muskelkörperchen und das was man eine zelle zu nennen habe. Arch. f. anat. u. phys., 1-27. **61.1.**
1645. Schulze, F. E. Beitrag zur entwickelung sgeschichte der quergestreiften muskelfaser. Arch. f. anat. u. phys., 385-392. taf. ix b. **62.1.**
1646. Stirling, Wm. On red and pale muscles in fishes. Stud. fr. phys. lab. Owens coll., Manchester, i, 1-71. **91.1.**
1647. Trinchese, S. Contribution à la connaissance des fuseaux musculaires. Arch. ital. biol., xiv, 221-230. **91.1.**
1648. Wagener, G. R. Ueber die entstehung der querstreifen auf den muskeln. Sitzb. Marburg. ges., 31-32. **80.1.**
1649. ——— Ueber die entstehung der querstreifen auf den muskeln und den davon abhängigen erscheinungen. Arch. f. anat. u. phys., anat. abth., 253-279, taf. x-xi. **80.2.**
1650. ——— Die entstehung der querstreifen auf den muskeln. Pflüger's Arch., xxx, 511-535, taf. iv. **83.1.**
1651. Weismann, A. Ueber das wachsen der quergestreiften muskeln nach beobachtungen am frosch. Zeitschr. f. rat. med., reihe 3, x, 263-284, taf. vi-vii. **61.1.**
1652. ——— Zur histologie der muskeln. Zeitschr. f. rat. med., reihe 3, xxiii, 26-45. **65.1.**

MYOTOMES.

1653. Chiarugi, G. Sur les myotomes et sur les nerfs de la tête postérieure et de la région proximale du tronc dans les embryons des amphibies anoures. Arch. ital. biol., xv, 229-239. **91.2.**
1654. Omitted.
1655. Dexter, Samuel. The somites and coelome in the chick. Anat. anz., vi, 284-289. **91.1.**
1656. Ebner, V. v. Urwirbel und neugliederung der wirbelsäule. Sitzb. Wien. akad., math.-naturw. kl., xcvii, abth. 3, 194-206, taf. ii. **88.3.**
1657. Ehrlich, F. Ueber den peripheren theil der urwirbel. Arch. f. mikr. anat., xi, 266-271, taf. xv. **76.1.**
1658. Fol, H. Recherches sur le développement des protovertébrés chez l'embryon du poulet. Arch. sc. phys. et. nat. Genève, xi, 104. **84.4.**
1659. Kaestner, S. Ueber die bildung von animalen muskelfasern aus dem urwirbel. Arch. f. anat. u. phys., anat. abth. suppl., 1-14, taf. i-ii. **90.1.**
1660. Killian. Zur metamerie des selachierkopfes. Verh. anat. ges., v, 85-107. **91.1.**
1661. Kollmann, J. Die rumpfsegmente menschlicher embryonen von 13 bis 35 urwirbeln. Arch. f. anat. u. phys., anat. abth., 39-88, taf. iii-v. **91.1.**

1662. Oppel, A. Ueber vorderkopfsomiten und kopfhöhle von Anguis fragilis. Arch. f. mikr. anat., xxxvi, 603-627, taf. xxx. **90.1.**

1663. Paterson, A. M. On the fate of the muscle-plate and the development of the spinal nerves and limb plexuses in birds and mammals. Q. J. M. S., xxviii, 109-129, pls. vii-viii. Stud. fr. biol. lab. Owen's coll., ii, 1890, 103-122, pls. vii-viii. **87.1.**

1664. Zimmermann. Ueber die metamerie des wirbeltierkopfes. Verh. anat. ges., v, 107-113. **91.1.**

NAILS.

665. Boas, J. E. V. Ein beitrag zur morphologie der nägel, krallen, hufe und klauen der säugethiere. Morph. jahrb., ix, 389-399, taf. xviii. **84.1.**

1666. Curtis, F. Sur le développement de l'ongle chez le foetus humain jusqu'à la naissance. Journ. anat. et phys. xxv, 125-186, pls. vi-vii. **89.2.**

1667. Heynold. Beitrag zur histologie und genese des nagels. Virchow's Arch., lxv, 270-272, taf. x, figs. 5-6. **75.1.**

1668. Kölliker, A. v. Ueber die entwickelung der nägel. München. med. wochenschr., xxxv, 157; Sitzb. phys.-med. ges. Würzburg, 53-62. **88.1.**

1669. ——— Die entwicklnng des menschlichen nagels. Zeitschr. wiss. zool., xlvii, 129-153, taf. xiii-xv. **88.2.**

1670. Zander, Richard. Die frühesten stadien der nägelentwickelung und ihre beziehung zu den digitalnerven. Arch. f. anat. u. phys., anat. abth., 103-143, taf. vi. **84.1.**

1671. ——— Untersuchungen über den verhornungsprocess; i. Die histogenese des nagels beim menschlichen foetus. Arch. f. anat. u. phys., anat. abth., 273-306, taf. xiii. **86.1.**

NERVES.

1672. Altmann, R. Bemerkungen zur Hensen'schen hypothese von der nervenentstehung. His's Arch., 344-348, taf. xiv. **85.1.**

1673. Balfour, F. M. On the development of the spinal nerves in elasmobranch fishes. (Abstract.) Proc. roy. soc. Lond., xxiv, 135-136. **75.1.**

1674. ——— On the spinal nerves of Amphioxus. Journ. anat. phys., x, 689-692. **76.2.**

1675. ——— On the development of the spinal nerves in elasmobranch fishes. Phil. trans. roy. soc. Lond., clxvi, 175-195. pls. xvi-xviii. **77.1.**

1676. Beard, J. Morphological studies; no. ii. The development of the peripheral nervous system of vertebrates. Q. J. M. S., xxix, 153-227, pls. xvi-xxi. **88.3.**

1677. ——— Prof. Rabl and the mode of development of the vertebrate peripheral nervous system. Anat. anz., v, 125-128. **90.1.**

1678. Bedot, Maurice. Recherches sur le développement des nerfs spinaux chez les tritons. Recueil zool. suisse, i, 161-188, pl. ix. **84.1.**

1679. Chiarugi, G. Sullo sviluppo di alcuni nervi cerebrali e spinale. Anat. anz., iv, 31-32. **89.1.**

1680. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; xiv. Ueber die erste anlage und entwicklung der motorischen rückenmarksnerven bei den selachiern. Mitth. zool. stat. Neapel, viii, 441-461, taf. xvii. **88.1.**

1681. ——— Studien zur urgeschichte des wirbelthierkörpers; xiii. Ueber nerven und gefässe bei Ammocoetes und Petromyzon planeri. Mitth. zool. stat. Neapel, viii, 233-306, taf. x-xv. **88.2.**

1682. Gaskell, W. H. On the relations between the function, structure, origin and distribution of the nerve fibres which compose the spinal and cranial nerves. Med.-chirurg. trans. London, lxxi, 363-375, pl. ii. **83.3.**

1683. ——— On the relation between the structure, function, distribution and origin of the cranial nerves; together with a theory of the origin of the nervous system of Vertebrata. Journ. phys., x, 153-211, pls. xvi-xx. **89.1.**

1684. Hensen, Victor. Ueber die entwicklung des gewebes und der nerven im schwanze der froschlarve. Virchow's Arch., xxxi, 51-73, taf. i-ii. **64.1.**

1685. ——— Zur entwicklung des nervensystems. Virchow's Arch., xxx, 176-186, taf. viii. **64.2.**

1686. His, W. Ueber die anfänge des peripherischen nervensystems. Arch. f. anat. u. phys., anat. abth., 455-482, taf. xvii-xviii. **79.1.**

1687. ——— Die entwickelung der ersten nervenbahnen beim menschlichen embryo; übersichtliche darstellung. Arch. f. anat. u. phys., anat. abth., 1887, 368-378. **88.1.**

1688. ——— Ueber die embryonale entwicklung der nervenbahnen. Anat. anz., iii, 499-506. **88.6.**

1689. Hubrecht, A. A. W. The peripheral nervous system in Palaeo- and Schizo-nemertini, one of the layers of the body wall. Q. J. M. S., xx, 431-442, pl. xxxii-xxxiii. **80.1.**

1690. ——— Researches on the nervous system of nemertines. Q. J. M. S., xx, 273-281, pl. xxiii. **80.2.**

1691. ——— Het peripherisch zenuwstelsel der nemertinen. Tijdschr. nederl. dierk. ver., v, afl. 3, 131-137. **81.1.**

1692. Klein, E. On the termination of the nerves in the mammalian cornea. Q. J. M. S., xx, 459-475, pl. xxxvii. **80.1.**

1693. Lebouc̨q, H. Recherches sur le développement et la terminaison des nerfs chez les larves de batraciens. Bull. acad. roy. Belg., sér. 2, xli, 446-449, pls. i-ii. **76.1.**

1694. Marshall, A. On the early stages of development of the nerves in birds. Journ. anat. phys., xi, 491-515, pl. xx-xxi; Stud. phys. lab. Cambridge, 88-111. **77.1.**

1695. Miklucho, M. N. Beiträge zur vergleichenden neurologie der wirbelthiere. Leipzig, 74 p., 1 pl. 4to. **70.1.**

1696. Paterson, A. M. The limb plexuses of mammals. Journ. anat. phys., xxi (1887), 611-634, pl. xiv; Stud. anat., anat. dept. Owens coll., i, 135-158, pl. v. **91.3.**

1697. ——— The morphology of the sacral plexus in man. Journ. anat. phys., xxi (1887), 407-412; Stud. anat., anat. dept. Owens coll., i, 159-165. **91.4.**

1698. Pouchet, *and* Tourneux. Contribution à l'histoire du développement du système nerveux périphérique. Gaz. méd. Paris, sér. 4, vi, 16. **77.1.**

1699. Ranvier, L. Des tubes nerveux en T et de leurs relations avec les cellules ganglionnaires. C. R. acad. sc. Paris, lxxxi, 1274-1276. **75.1.**

1700. ——— De la régénération des nerfs de l'épithélium antérieur de la cornée et de la théorie du développement continu du système nerveux. C. R. acad. sc. Paris, lxxxviii, 979-981. **79.2.**

1701. ——— On the terminations of nerves in the epidermis. Q. J. M. S., xx, 456-459, pl. xxxvi. **80.1.**

1702. Retzius, G. Untersuchungen über die nervenzellen der cerebrospinal-ganglien und der übrigen peripherischen kopfganglien mit besonderer rücksicht auf die zellenausläufer. Müller's Arch., anat. abth., 369-402, taf. xvii-xxii. **80.1.**

1703. Rouget, C. Observations sur le développement des nerfs périphériques chez les larves de batraciens et de salamandres; fibres primitives, fibres secondaires. C. R. acad. sc. Paris, lxxix, 306-309; 448-452. **74.1.**

1704. ——— Mémoire sur le développement des nerfs chez les larves des batraciens. Arch. de phys., sér. 2, ii, 801-853, pls. xxix-xxxiv. **75.1.**

1705. Sagemehl, M. Untersuchungen über die entwickelung der spinalnerven. Dorpat, 47 p., 2 pls. 4to. (Diss.) **82.1.**

1706. Trinchese, S. Comment les fibres musculaires en voie de développement s'unissent aux fibres nerveuses. Arch. ital. biol., vii, 376-379. **86.1.**

NERVES, CEPHALIC.

1707. Antonelli, A. Contribution à l'étude de la signification morphologique et de l'histologie du ganglion ciliaire. Arch. ital. biol., xiv, 132-135. **90.1.**

1708. Beard, John. The system of branchial sense organs and their associated ganglia in Ichthyopsida; a contribution to the ancestral history of vertebrates. Q. J. M. S., xxvi, 95-156, pl. viii-x; *also in* Marshall's Stud. biol. lab. Owen's coll., i, 170. **85.1.**

1709. ——— The ciliary or motoroculi ganglion and the ganglion of the ophthalmicus profundus in sharks. Anat. anz., ii, 565-575. **87.2.**

1710. Béraneck, E. Recherches sur le développement des nerfs crâniens chez les lézards (index bibliographique). Recueil zool. suisse, i, 519-603, pl. xxvii-xxx. **84.1.**

1711. Chiarugi, G. Lo sviluppo dei nervi vago, accessorio, ipoglosso e primi cervicali nei sauropsidi e nei mammiferi. Atti soc. tosc. sc. nat. Pisa, x, 149-245, tav. xi-xii. **89.2.** Abbreviated translation: Arch. ital. biol., xiii, 309-341, 423-443. **90.1.**

1712. ——— Osservazioni intorno alle prime fasi di sviluppo dei nervi encefalici nei mammiferi e in particolare sulla formazione del nervo olfattivo. Monitore zool. ital., ii, 47-60, tav. i. Translation: Arch. ital. biol., xv, 418-425. **91.1.**

1713. ——— Ulteriori osservazioni sullo sviluppo dell' XI e del XII paio di nervi cranici nei mammiferi. Monitore zool. ital., iii, 57-60. **92.1.**

1714. Froriep, A. Ueber ein ganglion des hypoglossus und wirbelanlagen in der occipitalregion. Arch. f. anat. u. phys., anat. abth., 279-302, taf. xvi. **82.2.**

1715. ——— Ueber anlagen von sinnesorganen am facialis, glossopharyngeus und vagus, über die genetische stellung des vagus zum hypoglossus und über die herkunft der zungenmusculatur. Arch. f. anat. u. phys., anat. abth., 1-55, taf. i-ii. **85.1.**

1716. ——— Ueber das homologen der chorda tympani bei niederen wirbelthieren. Anat. anz., ii, 486-493. **87.1.**

1717. ——— Zur entwickelungsgeschichte der kopfnerven. Verh. anat. ges., v, 55-65. **91.2.**

1718. Gaskell, W. H. On the relation between the structure, function and distribution of the cranial nerves. Proc. roy. soc. Lond., xliii, 382-390. **88.2.**

1719. Gegenbaur, C. Ueber die kopfnerven von Hexanchus und ihr verhältniss zur wirbeltheorie des schädels. Jen. zeitschr. f. naturw., vi, 497-559, taf. xiii. **71.1.**

1720. His, Wilhelm. Die morphologische betrachtung der kopfnerven. Arch. f. anat. u. phys., anat. abth., 379-453. **88.2.**

1721. His, Wilhelm, Jr. Zur entwicklungsgeschichte des acustico-facialgebietes beim menschen. Arch. f. anat. u. phys., anat. abth., suppl., 1-29, taf. i-ii. **89.1.**

1722. Julin, Ch. De la valeur morphologique du nerf latéral du Petromyzon. Bull. acad. roy. Belg., sér. 3, xiii, 309-309. **87.3.**

1723. Kaczander, G. Sulla radice dorsale del nervo ipoglosso nell' uomo e nei mammiferi domestici. Anat. anz., vi, 444-450. **91.1.**

1724. Kölliker, A. Ueber die erste entwicklung der nervi olfactorii. Sitzb. phys.-med. ges. Würzburg, 127-133. **90.5.**

1725. Kupffer, C. von. Die entwickelung der kopfnerven der vertebraten. Verh. anat. ges., V. vers. München, 22-54. **91.1.**

1726. Marshall, A. Milnes. The development of the cranial nerves in the chick. Q. J. M. S., xviii, 10-40, pls. ii-iii. **78 1.**

1727. ——— Observations on the cranial nerves of Scyllium. Q. J. M. S., xxi, 469-499, pl. xxvii. **81.1.**

1728. ——— On the head cavities and associated nerves of elasmobranchs. Q. J. M. S., xxi, 72-97, pls. v-vi. **81.2.**

1729. — ——— The segmental value of the cranial nerves. Journ. anat. phys., xvi, 305-354, pl. x. **82.2.**

1730. Martin, Paul. Die neuroblasten des oculomotorius und trochlearis. Anat. anz., v, 530-532. **90 1.**

1731. ——— Die erste entwicklung der kopfnerven bei der katze. Oesterreich. monatsschr. f. thierheil. Wien, xiv-337, 385. **90.3.**

1732. ——— Die entwickelung des neunten bis zwölften kopfnerven bei der katze. Anat. anz., vi, 228-232. **91.7.**

1733. Onodi, A. D. Neurologische untersuchungen an selachiern; 1. Das ganglion ciliare. 2. Die vagusgruppe. Math., naturw. berichte aus Ungarn, v, 179-188. **87.1.**

1734. Phisalix, C. Sur les nerfs crâniens d'un embryon humain de trente-deux jours. C. R. acad. sc. Paris, civ, 242-244. **87.2.**

1735. Rabl, K. Ueber das gebiet des nervus facialis. Anat. anz., ii, 219-227. **87.1.**

1736. Schwalbe, C. Das ganglion oculomotori; ein beitrag zur vergleichenden anatomie der kopfnerven. Jen. zeitschr. f. naturw. xiii, 173-264, taf. xii-xiv. **79.1.**

1737. Wijhe, J. W. van. Ueber die mesodermsegmente und die entwickelung der nerven des selachierkopfes. Verh. akad. wetensch. Amsterdam, xxii, art. 5, 50 p., taf. i-v. **82.1.**

NERVOUS TISSUE

1738. Beard, J. The histogenesis of nerve. Anat. anz., vii, 290-302. **92.2.**

1739. ——— The transient ganglion cells and their nerves in Raja batis. Anat. anz., vii, 196-206. **92.1.**

1740. Besser. Zur histogenese der nervösen elementtheile in den centralorganen neugeborenen menschen. Virchow's Arch., xxxvi, 305-334, taf. vii-viii. **66.1.**

1741. Boll, F. Die histologie und histiogenese der nervösen centralorgane. Arch. f. psychiatr. u. nervenkrankh. Berlin, iv, 1-138, taf. i-ii. **74.1.**

1742. Cajal, S. Ramon y. Sur l'origine et les ramifications des fibres nerveuses de la moelle embryonnaire. Anat. anz., v, 85-95, 111-119. **90.1.**

1743. ——— A quelle époque apparaissent les expansions des cellules nerveuses de la moelle épinière du poulet. Anat. anz., v, 609-613; 631-639. **90.3.**

1744. Corning, H. K. Ueber die entwicklung der substantia gelatinosa Rolandi beim kaninchen. Arch. f. mikr. anat., xxxi, 594-613. **88.1.**

1745. Dohrn, A. Studien zur urgeschichte des wirbeltierkörpers; xvii. Nervenfaser und ganglienzelle; histogenetische untersuchungen. Mitth. zool. stat. Neapel, x, 255-341, taf. xvi-xxiii. **91.2.**

1746. Gierke, Hans. Die stützsubstanz des centralnervensystems. Arch. f. mikr. anat., xxv, 441-554, taf. xx-xxi; xxvi, 129-228, taf. vi. **85.1.**

1747. Golgi, C. Sulla fina anatomia degli organi centrali del sistema nervoso. Rivista sper. di freniatr. e di med. legale Reggio-Emilia, xi, 72; 192. **85.1.**

1748. ——— Ueber den feineren bau des rückenmarkes. Anat. anz , v, 372-396; 423-435. **90 3.**

1749. Held, Hans. Die endigungsweise der sensiblen nerven im gehirn. Arch. f. anat. u. phys., anat. abth., 33-39, taf. i-ii. **92.1.**

1750. Herms, E. Ueber die bildungsweise der ganglienzellen im ursprungsgebiete des nervus acustico-facialis bei Ammocoetes. Sitzb. math.-phys. kl. München. akad., 333-354, 2 pls. **84.1.**

1751. His, Wilhelm. Die neuroblasten und deren entstehung im embryonalen mark. Abh. math.-phys. cl. sächs. ges. wiss., xxvi, 313-372, taf. iv; Arch. f. anat. u. phys., anat. abth., 249-300, taf. xvi-xix. **89.1.**

1752. ——— Histogenese und zusammenhang der nervenelemente. Arch. f. anat. u. phys., anat. abth., suppl., 95-117. **90.1.**

1753. Hoffmann, E. F. Ueber den zusammenhang der nerven mit bindegewebskörperchen und mit stomata des peritoneums, nebst einigen bemerkungen über das verhalten der nerven in dem letzteren. Wien, 11 p. taf. i-ii. **87.1.**

1754. Kölliker, A. v. Ueber Golgi's untersuchungen, den feineren bau des centralen nervensystems betreffend. Sitzb. phys.-med. ges. Würzburg, x. **87.4.**

1755. ——— Nervenzellen und nervenfasern. Verh. anat. ges., v, München (1891), 2-22; Biol. centralbl., xii, 35-51. **92.1.**

1756. Lachi, P. Contributo alla istogenesi della nevroglia nel midollo spinale del pollo. Atti soc. tosc. sc. nat. Pisa, xi, 267-310, tav. x-xii. **90.1.**

1757. Lachi, P. Contribution à l'histogenèse de la névroglie dans la moelle épinière du poulet. Arch. ital. biol., xv, 160-161. **91.1**.

1758. Lenhossék, Mich. von. Zur kenntniss der neuroglia des menschlichen rückenmarkes. Verh. anat. ges., v, 193-221. **91.2**.

1759. ——— Zur kenntnis der ersten entstehung der nervenzellen und nervenfasern beim vogelembryo. Verh. X. intern. med. kongress Berlin, ii, abth. i, anat., 115-124. **91.3**.

1760. ——— Zur ersten entstehung der nervenzellen und nervenfasern bei dem vogelembryo. Verh. naturf. ges. Basel, ix, 379-397. **91.4**.

1761. Magini, G. Sur la névroglie et les cellules nerveuses cérébrales chez les foetus. Arch. ital. biol., ix, 59-60. **88.1**.

1762. Merk, Ludwig. Ueber die anordnung der kerntheilungsfiguren im zentralnervensystem und der retina bei natterembryonen. Sitzb. Wien. akad., xcii; Biol. centralbl., v, 729-730. **85.1**.

1763. ——— Die mitosen im centralnervensysteme; ein beitrag zur lehre von wachsthume desselben. Denkschr. math.-naturw. cl. Wien. akad., liii, 1-42, taf. i-iv. **87.1**.

1764. Rauber, Anton. Die kerntheilungsfiguren im medullarrohr der wirbelthiere; i. Batrachier. Arch. f. mikr. anat., xxvi, 622-644, taf. xxxi. **86.1**.

1765. Schmidt, H. D. Ueber entwicklung der nervengewebe im menschlichen embryo. Chicago journ. of nerv. ment. disease, iv, 421-445, figs. 1-27. **77.1**.

1766. Valenti, G. Contribution à l'histogenèse de la cellule nerveuse et de la névroglie du cerveau de certains poissons chondrostéiques. Arch. ital. biol., xvi, 247-252. **91.1**.

1767. Vignal, W. Mémoire sur le développement des tubes nerveux chez les embryons des mammifères. Arch. de phys., xv, 513-535, pls. x, xi A. **83.1**.

1768. ——— Accroissement et longueur des tubes nerveux par formation des segments intercalaires. Arch. de phys., xv, 536-548, pl. xi B. **83.2**.

1769. ——— Sur le développement des éléments de la moelle des mammifères. Arch. de phys., xvi, 177-237, taf. viii-x; 364-426, taf. xii-xvi. **84.1**.

1770. ——— Formation et développement des cellules nerveuses de la moelle épinière des mammifères. C. R. acad. sc. Paris, xcix, 420-422. **84.2**.

1771. ——— Sur le développement des éléments de la substance grise corticale des circonvolutions cérébrales. C. R. acad. sc. Paris, cii, 1332-1334. **86.1**.

1772. ——— Recherches sur le développement des éléments des couches corticales du cerveau et du cervelet chez l'homme et les mammifères. Arch. de phys., xx, 228-254, pl. v-vi; 311-336, pl. ix-xii. **88.1**.

NEURENTERIC CANAL.

1773. Durham, Herbert E. Note on the presence of a neurenteric canal in Rana. Q. J. M. S., xxvi, 509-510, pl. xxvii. **86.1**.

1774. Giacomini, C. Sur le canal neurentérique et sur le canal anal dans les vésicules blastodermiques du lapin. Arch. ital. biol., x, 273-294. **88.1**.

1775. Kupffer, C. Ueber den canalis neurentericus der wirbeltiere. Sitzb. ges. f. morph. phys. München, iii, 1-5. **87.1**.

1776. Perényi, J. Ueber das verharren des blastoporus bei den fröschen. Math. u. naturw. berichte aus Ungarn, v, 253-259. **87.3**.

1777. Schanz, Fritz. Das schicksal des blastoporus bei den amphibien. Jen. zeitschr. f. naturw., xxi, 411-422, taf. xxiv. **87.1**.

1778. Sidebotham, Harold. Note on the fate of the blastopore in Rana temporaria. Q. J. M. S., xxix, 49-55, pl. v. **88.1**.

1779. Strahl, H. Ueber den canalis myeloentericus der eidechse. Sitzb. Marburg. ges., 37-41. **80.1**.

1780. ——— Zur entwicklung des canalis myeloentericus der eidechse. Sitzb. Marburg. ges., 54-55. **80.3**.

1781. ——— Ueber die entwickelung des canalis myeloentericus und der allantois der eidechse. Arch. f. anat. u. phys., anat. abth., 122-160, taf. vi-xii. **81.1**.

1782. ——— Ueber canalis neurentericus und allantois bei Lacerta viridis. His's Arch., 323-340, taf. xiv. **83.2**.

1783. Wijhe, J. W. van. Ueber den vorderen neuroporus und die phylogenetische function des canalis neurentericus der wirbelthiere. Zool. anz., vii, 683-687. **84.1**.

NEURON.

1784. Beard, J. A contribution to the morphology and development of the nervous system of vertebrates. Anat. anz., iii, 874-905. **88.5**.

1785. ——— Some annelidan affinities in the ontogeny of the vertebrate nervous system. Nature, xxxix, 259-261. **89.1**.

1786. Calberla, E. Zur entwicklung des medullarrohres und der chorda dorsalis der teleostier und der petromyzonten. Morph. jahrb., iii, 226-270, taf. xii-xiii. **77.1**.

1787. Clevenger, S. V. Plan of the cerebrospinal nervous system. Journ. nerv. ment. disease. Abstract: Am. assoc. adv. sc., xxix, 555-556. **80.1**.

1788. Goette, A. Beiträge zur entwicklungsgeschichte der wirbelthiere: iii. Ueber die entwicklung des central-nervensystems der teleostier. Arch. f. mikr. anat., xv, 139-200, taf. vii-x. **78.1**.

1789. Hoffmann, C. K. Ueber die metamerie des nachhirns und hinterhirns und ihre beziehung zu den segmentalen kopfnerven bei reptilienembryonen. Zool. anz., xii, 337-339. **89.1**.

1790. Kaczander, J. Ueber die beziehungen des medullarrohres zu dem primitivstreifen. Mitth. embryol. inst. univ. Wien, ii, 26-32. **87.1**.

1791. Klein, E. Histological notes; ii. Cilia in the central canal of the embryo chick. Q. J. M. S., xx. 476-477. **80.2**.

1792. Kupffer. Primäre metamerie des neuralrohrs der vertebraten. Sitzb. math.-phys. cl. akad. München, 469-476. **86.1**.

1793. Löwe, L. Beiträge zur vergleichenden morphogenesis des centralen nervensystems der wirbelthiere. Schenk's Mitth. embryol. inst., ii, 1-9, taf. i-ii. **80.1**.

1794. Lubimoff, Alexis. Embryologische und histogenetische untersuchungen über das sympathische und centrale cerebrospinal nervensystem. Virchow's Arch., lx, 217-273, taf. vii-viii. **74.1**.

1795. McClure, C. F. W. The segmentation of the primitive vertebrate brain. Journ. morph., iv, 35-56, pl. iii. **90.1**.

1796. Roux, Wilhelm. Ueber die lagerung des materials des medullarrohres an gefurchten froschei. Anat. anz., iii, 697-705. **88.2**.

1797. Schapringer, A. Ueber die bildung des medullarrohrs bei den knochenfischen. Sitzb. Wien. akad., lxiv, abth. 2, 653-656. **72.1**.

1798. Schultze, O. Ueber die entwickelung der medullarplatte des froscheies. Verh. phys.-med. ges. Würzburg. xxiii, 1-28, taf. i. **89.1**.

1799. Sedgwick, A. On the original function of the canal of the central nervous system of Vertebrata. Proc. phil. soc. Cambridge, iv, 325-328. **83.1**.

1800. Unger, L. Untersuchungen über die entwicklung der centralen nervengewebe. Sitzb. Wien. akad., lxxx, abth. 3, 282-311, 2 pls. **79.1**.

1801. Waldeyer. Ueber einige neue forschungsergebnisse auf dem gebiete der anatomie des nervensystems. Wien. med. blätter. xiv, 482-484. **91.2**.

NOSE.

1802. Blaue, Julius. Untersuchungen über den bau der nasenschleimhaut bei fischen und amphibien, namentlich über endknospen als endapparate des nervus olfactorius. His's Arch., 231-309, taf. xii-xiv. **84.1**.

1803. Born, G. Ueber die nasenhöhlen und den thränennasengang der amphibien. Morph. jahrb., ii, 577-646, taf. xxxix-xli. **76.1**.

1804. ——— Die nasenhöhlen und der thränennasengang der amnioten wirbelthiere; i. Saurien. ii. Vögel. Morph. jahrb., v, 62-140; 401-429, taf. vi-viii: xxiii-xxiv. **79.1**.

1805. ——— Die nasenhöhlen und der thränennasengang der amnioten wirbelthiere, iii. Morph. jahrb., viii, 188-232, taf. ix-x. **83.3**. (Compare 1815.)

1806. Disse, J. Die ausbildung der nasenhöhle nach der geburt. Arch. f. anat. u. phys., anat. abth., 29-54, taf. iii. **89.1**.

1807. Evetzky, Th. Zur entwicklungsgeschichte des thränennasenganges beim menschen. Arch. f. ophthal. Leipzig, xxxiv, 23-26. **88.1**.

1808. Fleischer, R. Beiträge zu der entwicklungsgeschichte des Jacobson'schen organs und zur anatomie der nase. Sitzb. phys.-med. soc. Erlangen, 8-19. **78.1**.

1809. Gehuchten, A. van. Contributions à l'étude de la muqueuse olfactive chez les mammifères. La cellule, vi, 395-406, pl. i. **90.2**.

1810. Herzfeld. Ueber das Jacobson'sche organ des menschen und der säugethiere. Zool. jahrb., iii, 551-574, taf. xxiii-xxiv. **88.1**.

1811. Hochstetter, F. Ueber die bildung der inneren nasengänge oder primitiven choanen. Verh. anat. ges., v, 145-151, **91.2**.

1812. Klein, E. The organ of Jacobson in the rabbit. Q. J. M. S., xxi, 549-570, pl. xxx-xxxi. **81.1**.

1813. Kölliker, A. Ueber die Jacobson'schen organe des menschen. Festschrift z. jubiläum F. v. Rinecker's. 11 p., 2 pl. 4to. **77.2**.

1814. Legal, E. Zur entwicklungsgeschichte des thränennasenganges bei säugethieren. Breslau, 32 p. (Inaug. diss.) **81.1**.

1815. ——— Die nasenhöhlen und der thränennasengang der amnioten wirbelthiere, iv. Morph. jahrb., viii, 353-372, taf. xv. **83.1**. (Compare 1804, 1805.)

1816. Marshall, A. Milnes. The morphology of the vertebrate olfactory organ. Q. J. M. S., xix, 300-340, pls. xiii-xiv. **79.1**.

1817. Putelli, F. Ueber das verhalten der zellen der riechschleimhaut bei hühnerembryonen früher stadien. Mitth. embryol. inst. univ. Wien, 26-29. **89.1**.

1818. Seydel, Otto. Ueber die nasenhöhle der höheren säugethiere und des menschen. Morph. jahrb., xvii, 41-99, taf. iv-vi. **91.1.**

1819. Zuckerkandl, E. Das periphere geruchsorgan der säugethiere; vergleichend-anatomische studie. Stuttgart. 7 pls. 8vo. **87.1.**

1820. ——— Die siebbeinmuscheln des menschen. Anat. anz., vii, 13-25. **92.1.**

NOTOCHORD.

1821. Barfurth, D. Zur entwickelung und regeneration der chorda dorsalis bei den urodelen amphibien. Anat. anz., vi, 104-106. **91.1.**

1822. Carlier, E. W. The fate of the notochord and development of the intervertebral disc in the sheep, with observations on the structure of the adult disc in these animals. Journ. anat. phys., xxiv, 573-583, pl. xx. **90.1.**

1823. Carius, F. Ueber die entwicklung der chorda und der primitiven rachenhaut bei meerschweinchen und kaninchen. Marburg, 33 p., 1 pl. (Diss.) **88.1.**

1824. Ehlers, E. Nebendarm und chorda dorsalis. Nachr. ges. wiss. univ. Göttingen, 390-404. **85.1.**

1825. Froriep, A. Kopftheil der chorda dorsalis bei menschlichen embryonen. Beiträge z. anat. embryol. als festschr. f. F. G. J. Henle, 26-40, taf. iii, 4to. **82.1.**

1826. Gerlach, Leo. Ueber die entodermale entstehungsweise der chorda dorsalis. Biol. centralbl., i, 21-25; 38-49. **81.1.**

1827. Hofmann, C. K. Ueber die entwickelungsgeschichte der chorda dorsalis. Festschrift. f. Henle, p. 41. Abstract: Zool. jahresber., Vert., 96-97. **82.1.**

1828. Kann, Max. Das vordere chordaende. Erlangen, 22 p., 2 pls. 8vo. (Phil. diss.) **88.1.**

1829. Keibel, Franz. Zur entwickelungsgeschichte der chorda bei säugern (meerschweinchen und kaninchen). Arch. f. anat. u. phys., anat. abth., 329-388, taf. xxii-xxv. **89.3.**

1830. Kölliker, A. Ueber die beziehungen der chorda dorsalis zur bildung der wirbel der selachier und einiger anderen fische. Verh. phys.-med. ges. Würzburg, ix, 193-242, taf. ii-iii. **59.1.**

1831. ——— Kritische bemerkungen zur geschichte der untersuchungen über die scheiden der chorda dorsalis. Verh. phys.-med. ges. Würzburg, n. f. iii, 336-345. **72.1.**

1832. ——— Ueber die chordahöhle und die bildung der chorda beim kaninchen. Sitzb. phys.-med. ges. Würzburg, 2-9. **83.1.**

1833. Kollmann, J. Die entwickelung der chorda dorsalis bei dem menschen. Anat. anz., v, 308-321. **90.1.**

1834. Kossmann, R. Bemerkungen über die sogenannte chorda des Amphioxus. Verh. phys.-med. ges. Würzburg, n. f. vi, 82-92, taf. iv. **74 1.**

1835. Lampert, K. Zur genese der chorda dorsalis beim Axolotl. Sitzb. phys.-med. soc. Erlangen, 37-57, taf. i. **83.1.**

1836. Lebouceq, H. Recherches sur le mode de disparition de la corde dorsale chez les vertébrés supérieurs. Arch. de biol., i, 718-736, pl. xxix. **80.1.**

1837. Lieberkühn, N. Ueber die chorda bei säugethieren. Arch. f. anat. u. phys., anat. abth., 399-438, taf. xx-xxi. **82.1.**

1838. ——— Ueber die chorda bei säugethieren. (Fortsetzung.) Arch. f. anat. u. phys., anat. abth., 435-452, taf. xix. **84.1.**

1839. Löwe, L. Zur kenntniss der säugethierchorda. Arch. f. mikr. anat., xvi, 597-612, taf. xxix, figs. i-x. **79.4.**

1840. Lwoff, B. N. Vergleichend-anatomische studien über die chorda und die chordascheide. (Russian with abstract in German.) Bull. soc. nat. Moscou, 227-342; 442-482, taf. iv-vii. **87.1.**

1841. ——— Ueber bau und entwickelung der chorda von Amphioxus. Mitth. zool. stat. Neapel, ix, 483-502, taf. xvi. **91.1.**

1842. Mihalkowics, V. von. Die chorda des Amphioxus lanceolatus. Arch. f. mikr. anat., xi, 425-441, taf. xxi. **76.1.**

1843. Müller, H. Ueber das vorkommen von resten der chorda dorsalis beim menschen. Zeitschr. f. rat. med., R. 3, ii. **58.1.**

1844. Müller, W. Ueber den bau der chorda dorsalis. Jen. zeitschr. f. naturw., vi, 327-353. **71.1.**

1845. ——— Beobachtungen des pathologischen institute zu Jena. Jen. zeitschr. f. naturw., vi, 327-495, taf. ix-xii. **71.2.**

1846. Nusbaum, J. Vorläufige mittheilung über die chorda der arthropoden. Zool. anz., vi, 291-295. **83.1.**

1847. ——— Bau, entwicklung und morphologische bedeutung der Leydig'schen chorda der lepidopteren. Zool. anz., vii, 17-21. **84.1.**

1848. Paulisch, O. Das vordere ende der chorda dorsalis und der Franck'sche] nasenkamm. Arch. f. anat. u. phys., anat. abth., 187-215, taf. xiii. **87.1.**

1849. Perényi, J. Beiträge zur entwickelung der chorda dorsalis und der perichordalen gebilde bei Torpedo marmorata. Math. naturw. berichte aus Ungarn, v, 218-240, taf. i-iv. Abstract: *ibid.*, iv, 214-217. **87.2.**

1850. Platt, Julia B. Fibres connecting the central nervous system and chorda in Amphioxus. Anat. anz., vii, 282-284. **92.1.**

1851. Rabl-Rückhard, H. Das gegenseitige verhältnis der chorda, hypophysis und des mittleren schädelbalkens bei haifisch-embryonen, nebst bemerkungen über die deutung der einzelnen theile des fischgehirns. Morph. jahrb., vi, 535-570, taf. xxvii-xxviii. **80.1.**

1852. Reichert, C. B. Ueber das vordere ende der chorda dorsalis bei frühzeitigen haifisch-embryonen (Acanthias vulgaris). Abh. akad. wiss. Berlin, 49-122, taf. ii. **77.1.**
1853. Robin, C. Mémoire sur l'évolution de la notocorde. Paris. **63.1.**
1854. Romiti, Guglielmo. De l'extremité antérieure de la corde dorsale et de son rapport avec la pôche hypophysaire ou de Rathke chez l'embryon du poulet. Arch. ital. biol., vii, 226-231. **86.1.**
1855. Strahl. Demonstrationen des chorda kanals, u. s. w. Anat. anz., iii, 740-743. **88.6.**

NUTRITION OF EMBRYO.

1856. Ahlfeld, Fr. Zur frage über den übergang geformter elemente von mutter auf kind. Centralbl. f. gynäk., i, 265-267. **77.3.**
1857. Colnstein, J., *and* Zuntz, N. Weitere untersuchungen zur physiologie des säugetier-fötus. (Aus dem tier-physiologischen laboratorium der landwirtschaftl. hochschule zu Berlin.) Pflüger's Arch., xlii, 342-392. **88.1.**
1858. Eschricht, D. F. De organis quae respirationi et nutritioni foetus mammalium inserviunt. Hafniae, 41 p., 4to. **37.1.**
1859. Liebermann, Leo. Embryochemische untersuchungen. Arch. phys., xliii, 71-151. **88.1.**

OESOPHAGUS.

1860. Mayer, S. Die membrana perioesophagealis. Anat. anz., vii, 217-221. **92.1.**
1861. Meuron, P. de. Sur le développement de l'oesophage. C. R. acad. sc. Paris, cii, 1401-1403. **86.2.**
1862. Neumann. Flimmerepithel im oesophagus menschlicher embryonen. Arch. f. mikr. anat., xii, 570-574. **76.1.**
1863. Opitz, W. Ueber die bedeutung des fruchtwassers für die ernahrung des kindes. Blinde endigung der speiseröhre. Centralbl. f. gynäk. Leipzig, xi, 734-735. **87.1.**
1864. Selenka, E. Die gaumentasche der wirbelthiere. Biol. centralbl., vii, 679-683. **81.1.**
1865. Strahl, H. Beiträge zur kenntnis des baues des oesophagus und der haut. Arch. f. anat. u. phys., anat. abth., 177-195, taf. xii. **89.3.**

OVARY.

1866. Balfour, F. M. On the structure and development of the vertebrate ovary. Q. J. M. S., xviii, 383-438, pls. xvii-xix. **78.2.**
1867. Beigel, Hermann. Zur naturgeschichte des corpus luteum. Arch. f. gynäk., xiii, 109-122, taf. ii-iii. **78.3.**
1868. Benckiser, Alfons. Zur entwicklungsgeschichte des corpus luteum. Arch. f. gynäk., xxiii, 350-366, taf. viii. **84.1.**
1869. Beneden, E. van. Contribution à la connaissance de l'ovaire des mammifères. Arch. de biol., i, 475-550, pls. xx-xxi. **80.2.**
1870. Bertè, F., *and* Cuzzi, A. Contributo all' anatomia dell' ovario della donna gravida. Rivista clin. Bologna, ser. 3, iv, 577-591, 3 pls. **84.1.**
1871. Call, E. L., *and* Exner, S. Zur kenntniss des Graaf'schen follikels und des corpus luteum beim kaninchen. Sitzb. Wien. akad., lxxi, abth. 3, 321-328, taf. i. **75.1.**
1872. Dalton, J. C. On the corpus luteum of menstruation and pregnancy. Trans. Am. med. assoc. Philadelphia, 100 p., 4 pls. (Prize essay.) **51.1.**
1873. ——— Report on the corpus luteum. Am. gyn. soc., pl. i-iv. **78.1.**
1874. Foulis, J. On the development of the ova and structure of the ovary in man and other Mammalia. Q. J. M. S., xvi, 190-221, pls. xvi-xviii. **76.1.**
1875. ——— The development of the ova, and the structure of the ovary in man and other Mammalia; with especial reference to the origin and development of the follicular epithelial cells. Journ. anat. phys., xiii, 353-381, pls. xix-xxi. **78.1.**
1876. Franck, L. Verhalten des echten gelben korpers im ovarium der stute. Deutsch. zeitschr. thiermed. Leipzig, ii, 227-228. **76.1.**
1877. Graaf, Regnerus de. De mulierum organis generationi inservientibus tractatus novus, demonstrans, etc. Lugduni Bataviae, xii, 334 p., 27 tab. **1672.1.**
1878. Grohe, F. Ueber den bau und das wachstum des menschlichen eierstocks und über einige krankhafte störungen desselben. Virchow's Arch., xxvi, 271-306, taf. vii. **63.1.**
1879. Harz, W. Beitrag zur histologie der ovarien der säugethiere. Arch. f. mikr. anat., xxii, 374-407, taf. xv. **83.1.**
1880. His, W. Beobachtungen über den bau des säugethiereierstockes. Arch. f. mikr. anat., i, 151-202, taf. viii-xi. **6.2.**
1881. Janosik, J. Zur histologie des ovarium. Sitzb. Wien. akad., xcvi, abth. 3, 172-193, taf. i-ii. **88.1.**
1882. Kapf, H. Untersuchungen über ovarium und dessen beziehungen zum peritoneum. Müller's Arch., 513-562, taf. xiv. **72.1.**
1883. Klebs. Die eierstockseier der wirbelthiere. Virchow's Arch., xxi, 362-366. **61.1.**
1884. ——— Die eierstockseier der säugethiere und vögel. Virchow's Arch., xxviii, 301-336, taf. x. **63.1.**

1885. Koster, W. Onderzoek omtrent de vorming van eieren in het ovarium der zoogdieren na de geboorte en de verhouding van het ovarium tot het buikvlies. Verslag. meded. akad. Amsterdam, afd. natuurk., R. 2, iii, 141-151, 1 pl. **69.1.**

1886. ——— Verdere onderzoekingen omtrent de vorming van folliculi Graafiani in het ovarium van den volwassen mensch. Verslag. meded. akad. Amsterdam, afd. natuurk., R. 2, vii, 47-70, pls. i-ii. **73.1.**

1887. Krause, C. Ei der säugethiere. Müller's Arch., 26-30. **37.1.**

1888. Lachi, Pilade. De la membrane granuleuse ovarienne et de ses éléments. Arch. ital. biol., vi, 62-67. **84.1.**

1889. Laulanié. Sur l'origine commune et le rôle variable de l'épithélium germinatif et des cordons sexuels dans l'ovaire. C. R. soc. biol. Paris, sér. 9, v, 4-8. **88.1.**

1890. Legge, F. Sul significato morfologico dei cordoni midollari dell' ovaja. Bull. accad. med. Roma, xiv, 366. **88.1.**

1891. Leopold, G. Untersuchungen über das epithel des ovarium und dessen beziehung zum ovulum. Leipzig, 19 p., 1 l., 1 pl. 8vo. (Diss.) **70.1.**

1892. Mayrhofer. Gegen die hypothese, die menschlichen eierstöcke enthielten männliche und weibliche eier. Arch. f. gynäk., ix, 442-447. **76.2.**

1893. Meckel von Hemsbach, H. Die bildung der für partielle furchung bestimmten eier der vögel, im vergleich mit dem Graafschen follikel und der decidua des menschen. Z. Z., iii, 420-434, taf. xv. **51.1.**

1894. Meyer, H. Ueber die entwicklung der menschlichen eierstöcke. Arch. f. gynäk., xxiii, 226-275, taf. iii-v. **84.1**

1895. Nagel, W. Beitrag zur anatomie gesunder und kranker ovarien. Arch. f. gynäk., xxxi, 327-362, taf. xi-xii. **67.1.**

1896. ——— Beitrag zur genese der epithelialen eierstocksgeschwulste. Arch. f. gynäk., xxxiii, 1-26, taf. i. **88.1.**

1897. ——— Ueber das vorkommen von primordialeiern ausserhalb der keimdrüsenanlage beim menschen. Anat. anz., iv, 496-498. **89.4.**

1898. ——— Zur anatomie des menschlichen eierstockes. Arch. f. gynäk., xxxvii, 491-494. **90.1.**

1899. Paladino, G. Ulteriori ricerche sulla distruzione e rinnovamento continuo del parenchima ovarico nei mammiferi. Napoli, 230 p., 9 pls. 8vo. **87.1.**

1900. ——— La destruction et le renouvellement continuel du parenchyme ovarique des mammifères. Arch. ital. biol., ix, 176-202. **88.1.**

1901. Pflüger, E. F. W. Ueber die eierstöcke der säugethiere und des menschen. Leipzig, iii, 124 p., 5 pls. 4to. **63.1.**

1902. Retzius, G. Die intercellularbrücken des eierstockeies und der follikelzellen sowie über die entwicklung der zona pellucida. Verh. anat. ges., iii, 10-12. **89.1.**

1903. Rouget, Ch. Recherches sur le développement des oeufs et de l'ovaire chez les mammifères, après la naissance. C. R. acad. sc. Paris, lxxxviii, 128-131. **79.1.**

1904. Ruge, Georg. Vorgänge am eifollikel der wirbelthiere. Morph. jahrb., xv, 491-554, taf. xviii-xxi. **89.1.**

1905. Schottländer, J. Beitrag zur kenntniss der follikelatresie nebst einigen bemerkungen über die unveränderten follikel in den eierstöcken der säugethiere. Arch. f. mikr. anat., xxxvii, 192-238, taf. xi. **91.1.**

1906. Schrön, O. Beitrag zur kenntniss der anatomie und physiologie des eierstocks der säugethiere. Zeitschr. wiss. zool., xii, 409-426, taf. xxxii-xxxiv. **63.1.**

1907. Schulin, K. Zur morphologie des ovariums. Arch. f. mikr. anat., xix, 442-513, taf. xxii-xxiv. **81.1.**

1908. Slavjansky, Kr. Zur normalen und pathologischen histologie des Graaf'schen bläschens. Virchow's Arch., li, 470-495, taf. xi. **70.1.**

1909. ——— Recherches sur la regression des follicules de Graaf chez la femme. Arch. de phys., i, 213-233, pl. x. **74.1.**

1910. Spiegelberg, O. Die entwicklung der eierstocksfollikel und der eier der säugethiere. Nachr. univ. u. ges. Göttingen, 201-208. **60.1.**

1911. ——— Drüsenschläuche im fötalen menschlichen eierstock. Virchow's Arch., xxx, 466-467, taf. xvi. **64.1.**

1912. Stuhlmann, Franz. Zur kenntnis des ovariums der aalmutter (Zoarces viviparus Cuv.). Abh. naturw. ver. Hamburg, x, 3-48, taf. i-iv. **87.1.**

1913. Thomson, Arthur. Recent researches on oogenesis. Q. J. M. S., xxvi, 591-606. **86.1.**

1914. Valentine, G. Ueber die entwicklung der follikel in dem eierstock der säugethiere. Müller's Arch., 526-535. **38.1.**

1915. Virchow, Hans. Durchtreten von granulosa-zellen durch die zona pellucida des säugethiereies. Arch. f. mikr. anat., xxiv, 113-116, taf. vii, fig. 6-9. **85.1.**

1916. Wagener, G. R. Bemerkungen über den eierstock und den gelben körper. Arch. f. anat. u. phys., anat. abth., 175-200, taf. vii-viii. **79.1.**

1917. Wagner, R. Einige bemerkungen und fragen über das keimbläschen (vesicula germinativa). Müller's Arch., 373-377, taf. viii, fig. 1-7. **35.1.**

1918. Waldeyer, W. Eierstock und nebeneierstock. Stricker's Handb. d. lehre v. geweben. 544-580. **71.1.**

OVULATION.

1919. Arnold, G. Ueber das zeitliche verhältniss der ovulation zur menstruellen blutung. Würzburg, 22 p. (Diss.) **87.1.**

1920. Auvard. Menstruation et ovulation. Gaz. hebdom., sér. 2, xxiv, 273-276. **87.1**

1921. Bischoff. Ueber ovulation und menstruation. Wien. med. wochenschr., 449-453; 473-477; 497-501; 521-525. **75.1.**
1922. Gerlach, L. Beiträge zur morphologie und physiologie des ovulationsvorganges der säugethiere. Sitzb. phys.-med. soc. Erlangen, 43-61. **90.1.**
1923. Hasse, C. Zur wanderung des menschlichen eies. Zeitschr. f. geburtsh. u. gynäk. Stuttgart, xxii, 406-412. **91.1.**
1924. Kehr, J. Die aufnahme des menschlichen eies in die tuba und seine fortleitung bis in den uterus; eine historisch-kritische studie. Jena, 44 p., 8vo. (Inaug. diss.) **85.1.**
1925. Lemière, G. Des rapports entre l'ovulation, la menstruation et la fécondation. Journ. sc. méd. Lille, xi, 175-183; 270-276. **88.1.**
1926. Leopold, G. Untersuchungen über menstruation und ovulation. Arch. f. gynäk., xxi, 347-408, taf. ii-iii. **83.1.**
1927. Mayrhofer. Ueber die gelben körper und die überwanderung des eies. Wien. med. wochenschr., xxxvi, 120-125. **76.1.**
1928. Ronget. Sur les organes érectiles de la femme et sur l'appareil musculaire tubo-ovarien, dans leurs rapports avec l'ovulation et la menstruation. Journ. de phys., i, 320-343; 479-496; 735-750. **58.1.**
1929 Steinhaus, J. Menstruation und ovulation in ihren gegenseitigen beziehungen. Leipzig, viii, 122 p. 8vo. **90.1.**
1930. Williams, John. Note on the discharge of ova, and its relation to the time of menstruation. Proc. roy. soc. Lond., xxiii, 439-444. **75.3.**

OVUM.

1931. Baer, Carolus Ernestus. De ovi mammalium et hominis genesi. Lipsiae, 40 p., 1 pl. 4to. **27.1.**
1932. Balbiani, M. Sur la constitution du germe dans l'oeuf animal avant la fécondation. C. R. acad. sc. Paris, lviii, 584-588; 621-625. **64.1.**
1933. Balfour, F. M. On the phenomena accompanying the maturation and fecundation of the ovum. Q. J. M. S., xviii, 109-131. **78.1.**
1934 Bambeke, Charles van. Sur les trous vitellins que présentent les oeufs fécondés des amphibiens. Bull. acad. Belg., sér. 2, xxx, 58-71. **70.1.**
1935. ——— De la présence du noyau de Balbiani dans l'oeuf des poissons osseux; communication préalable. Bull. soc. méd. Gand, 21 p. **73.1.**
1936. ——— Recherches sur embryologie des batraciens; i. Oeuf mûr non fécondé; ii. Oeuf fécondé. Bull. acad. Belg., sér. 2, lxi, 97-135, pl. i-ii. **76.2.**
1937. ——— Contributions à l'histoire de la constitution de l'oeuf: i. Rapport médiat de la vésicule germinative avec la périphérie du vitellus. Arch. de biol., iv, 803-832, pl. xxvii. **83.1.**
1938. ——— Note sur une inclusion rencontrée dans un oeuf de poule. Gand, 44 p., pl. i. **84.1.**
1939. ——— Contribution pour servir à l'histoire de la vésicule germinative. Bull. acad. Belg., sér. 3, xi, 14-28. **86.2.**
1940. Beddard, F. E. Observations on the ovarian ovum of Lepidosiren (Protopterus). Proc. zool. soc. Lond., 272-292, pls. xxviii-xxix. **86.1.**
1941. ——— Observations on the development and structure of the ovum in the Dipnoi. Proc. zool. soc. Lond., 505-527, pls. lii-liv. **86.2.**
1942. Bellonci, G. Intorno ad un principio di segmentazione e ad alcuni fenomeni degenerativi degli ovuli ovarici del topo e della cavia. Mem. accad. ist. Bologna, ser. 4, vi, 368-371, 1 tav. **85.2.**
1943. ——— Intorno al modo di genesi di un globulo polare nell' ovulo ovarico di alcuni mammiferi (topolino, cavia, coniglio). Mem. accad. ist. Bologna, ser. 4, vi, 363-368. **85.1.**
1944. Benecke, B. Ueber reifung und befruchtung des eies bei den fledermäusen. Zool. anz., ii, 304-305. **79.1.**
1945. Beneden, E. van. Recherches sur la composition et la signification de l'oeuf, basées sur l'étude de son mode de formation et des premiers phénomènes embryonnaires (mammifères, oiseaux, crustacés, vers). Mém. cour. acad. Belg., xxxiv, 285 p., 12 pls. **70.1.**
1946. ——— Contributions à l'histoire de la vésicule germinative et du premier noyau embryonnaire. Bull. acad. Belg., sér. 2, xli, 38-85, pl. i. **76.1.**
1947. Berg, E. Die eiweissschichte und das befruchtete eichen der säugethiere im eileiter. Allg. Wien. med. zeit., p. 469. **83.1.**
1948. Bischoff, Th. L. W. Ueber die bildung des säugethiereies und seine stellung in der zellenlehre. Sitzb. akad. München, i, 242-264, taf. i. **63.1.**
1949. ——— Ueber unrichtigkeit der angabe in Haeckels anthropogenie in bezug auf das ei der menschen und der anderen säugethiere. Sitzb. math.-naturw. kl. akad. München, 1-2. **76.1.**
1950. ——— Ueber die zeichen der reife der säugethiereier. Arch. f. anat. u. phys., anat. abth., 43-52. **78.1.**
1951. Blochmann, F. Ueber die reifung des eies bei ameisen und wespen. Heidelberg, 32 p., 1 pl. **86.1.**
1952. ——— Ueber die richtungskörper bei insekteneiern. Morph. jahrb., xii, 544-574, taf. xxvi-xxvii. **87.1.**
1953. ——— Bemerkungen zu den publikationen über die richtungskörper bei parthenogenetisch sich entwickelnden eiern. Morph. jahrb., xiii, 654-663. **88.1.**

1954. Blochmann, F. Ueber die zahl der richtungskörper befruchteten und unbefruchteten bieneneiern. Morph. jahrb., xv, 85-96. **89.2.**
1955. ——— Ueber die richtungskörper bei unbefruchtet sich entwickelnden insecteneiern. Verh. naturh.-med. ver. Heidelberg, n. f., iv, 239-241. **89.3.**
1956. Boveri, Th. Ueber die bedeutung der richtungskörper. München. med. wochenschr., xxxiii, 920-921. **86.1.**
1957. Bütschli, O. Gedanken über die morphologische bedeutung der sogenannten richtungskörperchen. Biol. centralbl., iv, 5-12. **84.1.**
1958. Carini, A. Zur lehre über die reife der eier. Mitth. embryol. inst. univ. Wien, ii, 69-76. **87.1.**
1959. Carnoy, J. B. La vésicule germinative et les globules polaires de l'Ascaris megalocephala. (La cytodiérèse de l'oeuf, etc., part. 2.) La cellule, ii, 1-76, pls. i-iv. **86.1.**
1960. ——— I. La vésicule germinative et les globules polaires chez divers nématodes. II. La segmentation chez les nématodes. (La cytodiérèse de l'oeuf, etc., part. 2.) La cellule, iii, 1-103, pls. v-viii. **86.2.**
1961. ——— I. Conférence donnée à la société belge de microscopie. II. Appendice: 1. Les globules polaires de l'Ascaris elavata; 2. Normalité des figures cinétiques; 3. Variations des cinèses; Terminologie concernant la division; Réponse à Flemming. La cellule, iii, 229-324, iii, pl. i. **87.1.**
1962. Duraute, Fr. Sulla struttura della macula germinativa delle ova di gallina. Ricerche lab. anat. norm. univ. Roma, 59-79, 1 pl. **72.1.**
1963. Eimer. Untersuchungen über die eier der reptilien. Arch. f. anat., viii, 216-248; 397-434, taf. xi-xii, xviii. **72.1.**
1964. Flemming, W. Ueber die bildung von richtungsfiguren in säugethiereiern beim untergang Graaf'scher follikel. His's Arch., 221-244, taf. x-xi. **85.1.**
1965. ——— Das ei von Ascidia canina. Verh. anat. ges. Berlin, iii, 13-14. **89.2.**
1966. Frommann, Carl. Ueber die struktur der dotterhaut des hühnereies. Sitzb. med.-naturw. ges. Jena. **78.1.**
1967. ——— Ei. Eulenberg's Encyclopädie d. ges. heilk., 2te aufl., v, 591-659. **86.3.**
1968. Gegenbaur, C. Ueber den bau und entwickelung der wirbelthier-eier mit partieller dottertheilung. Arch. f. anat. u. phys., 491-529, taf. xi. **61.1.**
1969. ——— Zur frage vom bane des vogeleies. Jen. zeitschr. f. med. u. naturw., i, 113-116. **64.1.**
1970. Gehuchten, A. van. Nouvelles observations sur la vésicule germinative et les globules polaires de l'Ascaris megalocephala. Anat. anz., ii, 751-760. **87.2.**
1971. Haacke, W. On the marsupial ovum, the mammary pouch and the male milk glands of Echidna hystrix. Proc. roy. soc. Lond., xxxviii, 72-74. **85.1.**
1972. ——— Das endergebnis aus Weismann's schrift Ueber die zahl der richtungskörper und über ihre bedeutung für die vererbung. Biol. centralbl., viii, 282-286. **88.2.**
1973. ——— Weismann's richtungskörpertheorie. Biol. centralbl., viii, 330-332. **83.3.**
1974. Hausmann, U. F. Ueber die zeugung und die entstehung des wahren weiblichen eies bei den säugethieren und beim menschen. Hanover, x. 136 p., 10 pls. 4to. **40.1.**
1975. Hickson, S. J. On the maturation of the ovum and the early stages in the development of Allopora. Q. J. M. S., xxx, 579-598, pl. xxxviii. **90.1.**
1976. Holl, M. Ueber die reifung der eizelle des huhns. Sitzb. Wien. akad., xcix, abth. 3, 311-370, 1 taf. **90.1.**
1977. ——— Ueber die menschliche eizelle. Anat. anz., vi, 551-556. **91.2.**
1978. Iwakawa, T. The genesis of the eggs in Triton. Q. J. M. S., xxii, 260-277, pls. xxii-xxiv. **82.1.**
1979. Kastschenko, N. Ueber den reifungsprozess des selachiereies. Zeitschr. wiss. zool., l, 428-442, taf. xvii. **90.1.**
1980. Koster, W. Remarque sur la signification du jaune de l'oeuf des oiseaux, comparée avec l'ovule des mammifères. Arch. néerl. sc. exact., i, 472-474. **66.1.**
1981. Lameere, Aug. Études sur la reproduction; i. A propos de la maturation de l'oeuf parthénogénétique. Bruxelles, 88 p., 3 pls. 8vo. **90.1.**
1982. ——— Études sur la reproduction; ii. Recherches sur la réduction karyogamique. Bruxelles, 73 p., 1 pl. 8vo. **90.2.**
1983. Legge, F. Il nucleo vitellino. Bull. accad. med. Roma, xiii, 338-352, 1 pl. **87.1.**
1984. Leichmann, G. Ueber bildung von richtungskörpern bei isopoden. Zool. anz., x, 533-534. **87.1.**
1985. Leuckart, R. Ueber die micropyle und den feineren bau der schalenhaut bei den insekteneiern, zugleich ein beitrag zur lehre von der befruchtung. Müller's Arch., 90-264, taf. viii-xi. **55.1.**
1986. Leydig, F. Zur kenntniss des tierischen eies. Zool. anz., x, 608-612; 624-627. **87.1.**
1987. ——— Beiträge zur kenntniss des tierischen eies im unbefruchteten zustande. Zool. jahrb., abth. anat., iii, 287-432, taf. xi-xvii. **88.3.**
1988. Lindgren, H. Ueber das vorhandensein wirklicher porenkanäle in der zona pellucida des säugethiereies und zeitweise einwanderung von granulösen zellen durch solche in das ei. Nord. med. arkiv, ix, 1; Arch f. anat. u. phys., anat. abth., 334-380, taf. xvi. **77.1.**
1989. Loewenthal, Nat. Zur kenntnis des keimfleckes im ureie einiger säuger. Anat. anz., iii, 363-373. **83.1.**
1990. ——— Ueber die rückbildung der eizellen und das vorkommen von leukocyten im keimepithel und in den eischläuchen. Intern. monatsschr. f. anat. u. phys., vi, 85-120, taf. v-vi. **89.1.**

1991. Loewenthal, Nat. Die befruchtung, reifung und teilung des eies von Oxyuris ambigua. Intern. monatsschr. f. anat. u. phys., vii, 341-374, 375-385, taf. xvi-xvii. **90.1**.
1992. Ludwig, H. Ueber die eibildung im thierreiche. Verh. phys.-med. ges. Würzburg, n. f. vii, 1-224, taf. i-ii; Arb. zool.-zoot. inst. Würzburg, i, 287-510, taf. xiii-xv. **74.1**.
1993. Maggiorani, C. Influenza del magnetismo sulla embriogenesi e sterilemento degli uovi. Atti accad. linc. Roma, ser. 4, i, 1-6. **84.1**.
1994. Morgan, T. H. The origin of the test cells of ascidians. Journ. morph., iv, 195-204, pl. viii. **90.1**.
1995. Müller, J. Ueber zahlreiche porenkanäle in der eikapsel der fische. Müller's Arch., 186-190, taf. viii. **54.1**.
1996. Nagel, W. Das menschliche ei. Arch. f. mikr. anat., xxxi, 342-423, taf. xx-xxi. **88.1**.
1997. Nathusius, W. v. Ueber die hüllen welche den dotter des vogeleies umgeben. Z. Z., xviii, 225-270, taf. xiii-xvii. **68.**.
1998. Nussbaum, M. Bildung und anzahl der richtungskörper bei cirripedien. Zool. anz., xii, 122. **89.1**.
1999. Oellacher, J. Beiträge zur geschichte des keimbläschens im wirbelthierreiche. Arch. f. mikr. anat., viii, 1-27, taf. i. **72.1**.
2000. ——— Die veränderungen des unbefruchteten keimes des hühnereies im eileiter und bei bebrütungsversuchen. Z. Z., xxii, 181-234, taf. xiii-xv. **72.2**.
2001. Owen, R. On the ova of the Echidna hystrix. Phil. trans. roy. soc. Lond., clxxi, 1051-1054, pl. xxxix. **80.1**.
2002. Paladino, G. I ponti intercellulari tra l' uovo ovario e le cellule follicolari, e la formazione della zona pellucida. Anat. anz., v, 254-259. **90.2**.
2003. Petitpierre, L. Ueber das eindringen von granulosazellen durch die zona pellucida menschlicher eier. Leipzig, 27 p. 8vo. (Inaug. diss.) **89.1**.
2004. Platner, Gustav. Ueber die bedeutung der richtungskörperchen. Biol. centralbl., viii, 718-720. **89.1**.
2005. Purkinje, J. E. Symbolae ad ovi avium historiam ante incubationem. Leipzig, 24 p., 2 pls. 4to. **30.1**.
2006. Ramsay, E. P. Description of the marsupial egg of Echidna hystrix. Ann. mag. nat. hist., ser. 5, xvi, 479. **85.1**.
2007. Rauber, A. Ueber secundären dotter in der keimblase von säugethieren. Zool. anz., iii, 591-594. **80.4**.
2008. Rückert, J. Zur entwickelungsgeschichte des ovarialeies bei selachiern. Anat. anz., vii, 107-158. **92.1**.
2009. Sabatier, A. Contribution à l'étude des globules polaires et des éléments éliminés de l'oeuf en général, part. i. Trav. lab. zool. Montpellier, sér. 1, v, 111-133, pls. xii-xiii. **83.3**.
2010. ——— Contribution à l'étude des globules polaires et des éléments éliminés de l'oeuf en général; part. ii. Théorie de la sexualité. Trav. lab. zool. Montpellier, sér. 1, v, 135-235; Revue sc. nat., 1-127, pls. i-ii. **84.** .
2011. Schütz, J. Ueber den dotterkern, dessen entstehung, structur, vorkommen und bedeutung. Bonn, 21 p., 1 pl. 4to. (Inaug. diss.) **82.1**.
2012. Sheldon, Lilian. The maturation of the ovum in the Cape and New Zealand species of Peripatus. Q. J. M. S., xxx, 1-29, pls. i-iii. **89.1**.
2013. Solger, Bernhard. Die richtungskörperchen von Balanus. Zool. anz., xiii, 607-609. **90.1**.
2014. Strahl, H. Ueber das wachstum der eier von Lacerta agilis. Sitzb. Marburg. ges., 45-48. **83.7**.
2015. Stricker, S. Beitrag zur kenntniss des hühnereies. Sitzb. Wien. akad., liv, 116-122. **66.1**.
2016. Stuhlmann, F. Die reifung des arthropodeneies. Biol. centralbl., vi, 397-402. **86.1**.
2017. Thomson, Allen. Ovum. Todd's Cyclop. anat., v, 1-142. **59.1**.
2018. Török, A. v. Die formative rolle der dotterplättchen beim aufbau der gewebestructur. Centralbl. f. med. wiss., xii, 257-261. **74.1**.
2019. Tourneux, F., *and* Hermann, G. Sur la disparition de la zone pellucide dans l'oeuf de la lapine pendant les premiers jours qui suivent la fécondation. C. R. soc. biol. Paris, sér. 8, iv, 49-50. **87.1**.
2020. Vejdovsky, Frz. Entwickelungsgeschichtliche untersuchungen; reifung, befruchtung und die ersten furchungsvorgänge des Rhynchelmis-eies. Prag, 166 p., 10 pls. 8vo. **88.1**.
2021. Virchow, Hans. Durchtreten von granulosazellen durch die zona pellucida des säugethiereies. Arch. f. mikr. anat., xxiv, 113-116, taf. vii, fig. 6-9. **85.1**.
2022. Virchow, R. Ueber die dotterplättchen bei fischen und amphibien. Z. Z., iv, 236-241. **53.1**.
2023. Wagner. Einwanderung der granulosazellen. Sitzb. Marburg. ges., 132. **77.1**.
2024. Weismann, A. Richtungskörper bei parthenogenetischen eiern. Zool. anz., ix, 570-573. **86.1**.
2025. ——— Ueber die zahl der richtungskörper und über ihre bedeutung für die vererbung. Jena, v, 75 p. **87.1**.
2026. ——— On the signification of the polar globules. Nature, xxxvi, 607-609. **87.2**.
2027. ——— Das zahlengesetz der richtungskörper und seine entdeckung. Morph. jahrb., xiv, 499-506. **88.2**.
2028. Weismann, A., *and* Ischikawa. Ueber die bildung der richtungskörper bei thierischen eiern. Ber. naturf. ges. Freiburg i. B., iii, 1-44, taf. i-iv. **87.1**.
2029. ——— Weitere untersuchungen zum zahlengesetz der richtungskörper. Zool. jahrb., anth. anat., iii, 575-610, taf. xxv-xxviii. **88.4**.
2030. Whitman, C. O. Changes preliminary to cleavage in the egg of Clepsine. Proc. Am. assoc. adv. sc., xxvii, 263-270. **78.1**.
2031. ——— The eggs of Amphibia. Am. nat., xxii, 857. **88.1**.

2032. Wielowiejski, H. von. Vorläufige bemerkungen über die eizelle. Biol. centralbl., iv, 360-370. **94.1.**
2033. ——— Das keimbläschenstadium des geschlechtskernes; ein beitrag zur bildungsgeschichte der geschlechtsproducte. Zool. anz., viii, 723-728. **85.1.**

PANCREAS.

2034. Göppert, Ernst. Die entwicklung und das spätere verhalten des pankreas der amphibien. Morph. jahrb., xvii, 100-122, taf. vii. **91.1.**
2035. Laguesse, E. Développement du pancréas chez les poissons osseux. C. R. soc. biol. Paris, sér. 9. i ,342-343. **89.1.**
2036. Schenk, S. L. Die bauchspeicheldrüse des embryo. Schenk's Anat.-phys. untersuch. Wien, 1-17. **72.2.**
2037. Stoss. Zur entwickelungsgeschichte des pankreas. Anat. anz., vi, 666-669. **91.1.**

PERICARDIUM.

2038. Oellacher, J. Ueber die erste entwicklung des herzens und der pericardial- oder herzhöhle bei Bufo cinereus. Arch. f. mikr. anat., vii, 157-165, taf. xvi. **71.1.**

PHARYNX.

2039. Seessel, A. Zur entwicklungsgeschichte des vorderdarms. Arch. f. anat. u. phys., anat. abth., 1877, 449-467, taf. xx-xxi. **78 1.**

PINEAL GLAND.

2040. Ahlborn, Fr. Ueber die bedeutung der zirbeldrüse. Z. Z., xl, 331-337, taf. xviii. **84 1.**
2041. Beard, J. The parietal eye in fishes. Nature, xxxvi, 246-248, 340-341. **87.3.**
2042. —— —— Morphological studies; no. i. The parietal eye of the cyclostome fishes. Q. J. M. S., xxix, 55-73, pls. vi-vii. **89.2.**
2043. Béraneck, E. Ueber das parietalauge der reptilien. Jen. zeitschr. f. naturw., xxi, 374-410, taf. xxii-xxiii. **87.1.**
2044. Ehlers, E. Die epiphyse am gehirn der plagiostomen. Z. Z., xxx, suppl., 607-634, taf. xxv-xxvi. **78.1.**
2045. Eycleshymer, A. Paraphysis und epiphysis in Amblystoma. Anat. anz., vii, 215-217. **92.1.**
2046. Flesch, Max. Ueber die deutung der zirbel bei den säugetieren. Anat. anz., iii, 173-176. **88.1.**
2047. Francotte, P. Contribution à l'étude du développement de l'épiphyse et du troisième oeil des reptiles. Bull. acad. Belg., sér. 3, xiv, 810-840, pl. i. **87.1.**
2048. ——— Recherches sur le développement de l'épiphyse. Arch. de biol., viii, 757-821, pls. xxxix-xl. **88.1.**
2049. Graaf, de. Zur anatomie und entwickelung der epiphyse bei amphibien und reptilien. Zool. anz., ix, 191-194. **86.1.**
2050. Hill, Charles. Development of the epiphysis in Coregonus albus. Journ. morph., v, 503-510. **91.1.**
2051. Julin, Charles. De la signification morphologique de l'épiphyse (glande pinéale) des vertébrés. Bull. sc. nord France, sér. 2, x, 81-141, pls. i-iii. **87.1.**
2052. Kölliker, A. v. Ueber das zirbel oder scheitelauge. Sitzb. phys.-med. ges. Würzburg, 51-52. **87.5.**
2053. Leydig, Fr. von. Das parietalorgan der reptilien und amphibien kein sinneswerkzeug. Biol. centralbl., viii, 707-718. **88.2.**
2054. ——— Das parietalorgan. Biol. centralbl., x, 278-285. **90.1.**
2055. Lieberkühn, N. Ueber die zirbeldrüse. Sitzb. Marburg. ges., 18-19. **71.1.**
2056. McKay, W. J. On the development and structure of the pineal eye in Hinulia and Grammatophora. Rep. Austr. assoc. sc. Sydney, i, 332-334. **89.1.**
2057. Mihalkowics, Victor v. Entwicklung der zirbeldrüse. Centralbl. f. med. wiss., xii, 241-242. **74.2.**
2058. Owen, R. On the homology of the conario-hypophysial tract or the so-called pineal and pituitary glands. Journ. Linn. soc. Lond., xvi, 131-149. **82.1.**
2059. Owsjannikow, Ph. Ueber das dritte auge bei Petromyzon fluviatilis nebst einigen bemerkungen über dasselbe organ bei anderen thieren. Mém. acad. sc. St. Pét., sér. 7, xxxvi, 26 p., taf. i, **88.1.**
2060. Rabl-Rückhard, H. Zur deutung der zirbeldrüse (epiphysis). Zool. anz., ix, 405-407. **86.1.**
2061. Ritter, W. E. The parietal eye in some lizards from the western United States. Bull. mus. comp. zool., xx, 209-228, pls. i-iv. **91.1.**
2062. Spencer, W. Baldwin. On the presence and structure of the pineal eye in Lacertilia. Q. J. M. S., xxvii, 165-238, pls. xiv-xx. **86.1.**
2063. Strahl, H., *and* Martin E. Die entwickelung des parietalauges bei Anguis fragilis und Lacerta vivipara. Arch. f. anat. u. phys., anat. abth., 146-163, taf. x. **88.1.**
2064. Wiedersheim, R. Ueber das parietalauge der saurier. Anat. anz., i, 148-149. **86.1.**

PLACENTA.

2065. Ackermann, Th. Zur normalen und pathologischen anatomie der menschlichen placenta. Intern. beitr. wiss. med. Berlin, i, 583-616, 2 pls. **91.1.**

2066. Ahlfeld, C. Ueber placenta praevia. München. med. wochenschr., xxxv, 390. **88.1.**

2067. Auvard, A. Dimensions de l'oeuf et insertion du placenta. Travaux d'obstétr. Paris, ii, 368-377. **89.1.**

2068. Baer, C. E. von. Untersuchungen über die gefässverbindungen zwischen mutter und frucht in den säugethieren; ein glückwunsch zur jubelfeier Samuel Thomas von Sömmerings. Leipzig, 30 p., 1 pl. fol. Königsberg. **28.1.**

2069. Balfour, F. M. On the evolution of the placenta and on the possibility of employing the characters of the placenta in the classification of the Mammalia. Proc. zool. soc. Lond., 210-212. **81.2.**

2070. Bassett, J. Untersuchung der placenta bei drillingen. Obstetr. trans., xxiii, 129-130. **82.1.**

2071. Baume. Ueber die entwickelung der menschlichen placenta. Wien. klin. wochenschr., iv, 618. **91.1.**

2072. Bayer. Die hypertrophie der muskelfasern im graviden uterus; ein beitrag zur lehre vom unteren segment und der placenta praevia. Centralbl. f. gynäk., xiii, 539. **89.1.**

2073. Beauregard, *and* Boulart. Note sur la placenta des ruminants. Robin's Journ., xxi, 93-99, pl. v. **85.1.**

2074. Beneden, Ed. van. De la fixation du blastocyste à la muqueuse utérine chez le murin (Vespertilio murinus). Bull. acad. Belg., sér. 3, xv, 17-27. **88.4.**

2075. ——— De la formation et de la constitution du placenta chez le murin (Vespertilio murinus). Bull. acad. Belg., sér. 3, xv, 351-364. **88.5.**

2076. Bernard, Claude. Sur une nouvelle fonction du placenta. C. R. acad. sc. Paris, xlviii, 77-86. **59.1.**

2077. Omitted.

2078. Bloch, Louis. Ueber den bau der menschlichen placenta. Beitr. pathol. anat., iv, 559-592, taf. xxi-xxv. **89.1.**

2079. Bossi, L. M., *and* Conti, A. Contributo allo studio anatomico e clinico delle anomalie della placenta. Mem. accad. med. Genova, 1887, 11-22. **88.1.**

2080. Boulart, B. Note sur le placenta du Cervus mexicanus. C. R. soc. biol. Paris, sér. 9, v, 422. **88.1.**

2081. Braxton, Hicks. The anatomy of the human placenta. Obstetr. trans., xiv, 149-207, pls. i-vii. **73.1.**

2082. ——— Some remarks on the anatomy of the human placenta. Journ. anat. phys., vi, 405-410. **72.1.**

2083. Breschet, G. Recherches anatomico-pathologiques et chimiques sur la matière colorante du placenta de quelques animaux. Ann. sc. nat., xix, 379-389. **30.1.**

2084. Bumm, E. Utero-placentargefässe. München. med. wochenschr., xxxvi, 454; Archiv f. gynäk., xxxv, 520. **89.1.**

2085. ——— Ueber die gefässe der placenta. München. med. wochenschr., xxxvi, 558-559. **89.2.**

2086. ——— Zur kenntniss der utero-placentargefässe. Arch. f. gynäk., xxxvii, 1-15, taf. i-iii. **90.1.**

2087. ——— Ueber die entwickelung der menschlichen placenta. München. med. wochenschr., xxxviii, 563-564. **91.1.**

2088. Cauvenberghe, Charles van. Sur l'anatomie physiologique et la pathologie du placenta. Gand, 203 p. (Diss.) **71.1.**

2089. Chapman, H. C. Placenta of Macacus cynomologus. Proc. acad. nat. sc. Philadelphia, 1879, 146-147. **80.1.**

2090. ——— The placenta and generative apparatus of the elephant. Journ. acad. nat. sc. Philadelphia, ser. 2, viii, 413-422, pl. xlviii-l. **81.2.**

2091. Chatellier, H. Étude sur un point de l'anatomie du placenta chez les femelles du rat blanc. Nouv. arch. obstétr. et gynéc. Paris, i, 488-491. **85.1.**

2092. Cohnstein. Beiträge zur lehre der placentarverwachsung. Arch. f. gynäk., xxxvi, 371-398. **89.1.**

2093. Colucci, Vincenzo. Sulla vera natura glandolare della porzione materna della placenta nella donna e negli animali. Mem. accad. ist. Bologna, vii, 133-158, tav. i-iii. **85.1.**

2094. Coste. Formation du placenta dans l'espèce humaine. C. R. acad. sc. Paris, i, 208. **35.1.**

2095. Creighton, Ch. On the formation of the placenta in the guinea-pig. Journ. anat. phys., xii, 534-590, pls. xix-xx. **78.1.**

2096. ——— Further observations on the formation of the placenta in the guinea-pig. Journ. anat. phys., xiii, 173-182, pl. xvi. **79.1.**

2097. Curie, Eugène. Sur la communication directe placentaire de la mère au foetus. C. R. soc. biol. Paris, sér. 8, i, 733-736. **84.1.**

2098. Dalrymple, J. On the structure and functions of the human placenta. Med.-chir. trans. Lond., xxv, 21-29, 1 pl. **42.1.**

2099. Dastre, C. Du placenta foetal des pachydermes. Ann. de gynéc., v, 66-67. **76.2.**

2100. Delore, X. Étude de la circulation maternelle dans le placenta. Ann. de gynéc., i, 405-417, pls. i-ii. **74.1.**

2101. Dugès, A. Lettre relative à la placentation du Dasypus novemcinctus. Ann. sc. nat., zool., sér. 6, ix, art. 3, 2 p. **80.1.**

2102. Duncan, J. M. Note of a proof of the free intercommunication near the chorionic surface, between different parts of the system of maternal cells or blood caverns of the placenta, in the same, and in different cotyledons. Edinb. obstetr. soc., iii, 116-121. **75.1.**

2103. Duval, M. Sur les premières phases du développement du placenta du cobaye. C. R. soc. biol. Paris, sér. 8, iv, 148-150. **87.1.**
2104. ——— Sur les premières phases du développement du placenta du lapin. C. R. soc. biol. Paris, sér. 8, iv, 425-427. **87.2.**
2105. ——— Les placentas discoïdes en général à propos du placenta des rongeurs. C. R. soc. biol. Paris, sér. 8, v, 675-676. **88.1.**
2106. ——— Les placentas discoïdes. C. R. soc. biol. Paris, sér. 8, v, 729-732. **88.2.**
2107. ——— Le placenta des rongeurs. Journ. anat. et phys., xxv, 309-342, pls. xiv-xv; 573-627, pls. xviii-xix. **89.1.**
2108. ——— Le placenta des rongeurs. Journ. anat. et phys., xxvi, 1-48; 273-344, pls. i-ii. **90.1.**
2109. ——— Le placenta des rongeurs; part. 2. De l'invasion des feuillets chez les rongeurs. Journ. anat. et phys., xxvi, 521-601, pl. xv. **90.2.**
2110. ——— L'ectoplacenta de la souris et du rat. C. R. soc. biol. Paris, sér. 9, ii. 567-568. **90.4.**
2111. ——— La couche plasmodiale endovasculaire du placenta maternel. C. R. soc. biol. Paris, sér. 9, ii, 605-606. **90.5.**
2112. ——— Le placenta des rongeurs. Journ. anat. et phys., xxvii, 24-73, pls. i-iv; 344-395, pls. xv-xviii. **91.1.**
2113. Eckardt, C. Th. Beiträge zur anatomie der menschlichen placenta. Zeitschr. f. geburtsh. u. gynäk., xix, 193-235, taf viii-x. **90.1.**
2114. Edwards, A. Milne. Observations sur la conformation du placenta chez le Tamandua. Ann. sc. nat., sér. 5, xv, art. 16, 4 p., pl. v. **72.1.**
2115. Ercolani, G. B. Sul processo formativo della porzione glandulare o materna della placenta. Mem. accad. ist. Bologna, ser. 2, ix, 363-432, tav. i-vi. **70.1.**
2116. ——— Delle malattie della placenta. Mem. accad. ist. Bologna, ser. 2, x, 491-554, tav. vii. **70.2.**
2117. ——— De la portion maternelle du placenta chez les mammifères. Journ. zool., i, 472-480, pl. xxiv. **72.1.**
2118. ——— Sulla parte che hanno le glandule otricolari dell' utero nella formazione della porzione materna della placenta. Mem. accad. ist. Bologna, ser. 3, iii, 264-312, tav. i-iv. **73.1.**
2119. ——— Della struttura anatomica della caduca uterina nei casi di gravidanza extrauterina nella donna. Mem. accad. ist. Bologna, ser. 3, iv, 397-414, tav. i. **74.1.**
2120. ——— Della placenta nei mostri per inclusione e nei casi di gravidanza extrauterina nella donna e in alcuni animali. Mem. accad. ist. Bologna, ser. 3, v, 527-541. **75.1.**
2121. ——— Sulle errate apparenze macroscopiche che hanno impedito fino ad ora di conoscere l' intima struttura della placenta, ecc. Arch. sc. med. Torino, i, 420-441. **76.1.**
2122. ——— Sulla unità del tipo anatomico della placenta nei mammiferi e nell' umana specie e sull' unità fisiologica della nutrizione dei feti in tutti i vertebrati. Mem. accad. ist. Bologna, ser. 3, vii, 271-346, tav. i-v. **77.1.**
2123. ——— Nuove ricerche sulla placenta nei pesci cartilaginosi e nei mammiferi e delle sue applicazioni alla tassonomia zoologica e all' antropogenia. Mem. accad. ist. Bologna, ser. 3, x, 601-982, tav. i-xi. **80.1.**
2124. ——— Nuove ricerche di anatomia normale e patologica sulla placenta dei mammiferi e della donna. (Tre lettere al chiarissimo Signore Prof. Alberto Kölliker.) Mem. accad. ist. Bologna, ser. 4, iv, 707-782, tav. i-iii. **83.1.** Résumé français par l'auteur: Arch. ital. biol., iv, 179-192. **83.2.**
2125. ——— Sulla alterazione patologiche portate dalla sizilide nella placenta umana. Bull. sc. med. Bologna, ser. 6, xi, 217-269, pl. i. **83.3.**
2126. Fleischmann, Albert. Ueber die erste anlage der placenta bei den raubtieren. Sitzb. phys.-med. soc. Erlangen, xix, 1-3. **86.1.**
2127. ——— Entwickelung und structur der placenta bei raubthieren. Sitzb. preuss. akad. Berlin, xxxv, 661-670. **91.1.**
2128. Flourens. Recherches sur les communications vasculaires entre la mère et le foetus. Ann. sc. nat., zool., sér. 2, v, 65-68. **36.1.**
2129. Franck, L. Accessorische placenten beim rinde. Deutsche zeitschr. thiermed. vergl. path. Leipzig, i, 70-73. **75.3.**
2130. Frommel, R. Zur entwicklung der decidua und placenta bei mäusen. Mitth. morph.-phys. ges. München: Aerztl. intell. München, xxx, 311. **83.1.**
2131. ——— Entwickelung der placenta. München. med. wochenschr., xxxv, 424. **88.1.**
2132. ——— Ueber die entwickelung der placenta von Myotus murinus; ein beitrag zur entwickelung der discoidalen placenta. Wiesbaden, 41 p., 12 pl. fol. **88.2.**
2133. Garrod, A. H., *and* Turner, W. The gravid uterus and placenta of Hyomoschus aquaticus. Proc. zool. soc. Lond., 682-686, pl. xliv. **78.1.**
2134. Gervais, P. Addition au mémoire de M. Turner. Journ. zool., i, 323-324, pl. xvii. **72.1.**
2135. Godet, R. Recherches sur la structure intime du placenta du lapin. Neuveville, 48 p., 2 pls. Berne. (Inaug. diss.) **77.1.**
2136. Goodsir, J. Structure of the human placenta. Goodsir's Anat. path. observations, Edinburg, 50-54. **45.1.**
2137. Gottschalk, S. Beitrag zur entwickelungsgeschichte der menschlichen placenta. Arch. f. gynäk., xxxvii, 251-278, taf. viii. **90.1.**

2138. Gottschalk, S. Weitere studien über die entwickelung der menschlichen placenta. Arch. f. gynäk., xl, 169-244, taf. ii-iv. **91.1.**
2139. Greman, M. J. Observations on the placentation of the cat. Am. nat., xxiii, 645-647. **89.1.**
2140. Hart, D. Berry. The minute anatomy of the placenta in extrauterine gestation. Edinb. med. journ., no. clxii, 344-347, figs. i-viii. **89.1.**
2141. Harting, P. Het ei en de placenta van Halicore dugong met een overzicht van de placentavorming bij zoogdieren van verschillende orden. Utrecht, 65 p., 2 pls. 8vo. (Inaug. diss.) **78.1.**
2142. ——— On the ovum and placenta of the dugong. (Abstract by Prof. Turner.) Journ. anat. phys., xiii, 116-117. **79.1.**
2143. Hegar. Die placenta materna am ende der schwangerschaft. Monatschr. f. geburtsk., xxix, 1-11. **67.1.**
2144. Heinricius, G. Ueber die entwickelung und structur der placenta beim hunde. Arch. f. mikr. anat., xxxiii, 419-440, taf. xxv-xxvi. **89.1.**
2145. ——— Die entwickelung der hunde-placenta. Sitzb. preuss. akad. Berlin, ix, 111-117. **89.2.**
2146. ——— Ueber die entwickelung und structur der placenta bei der katze. Arch. f. mikr. anat., xxxvii, 357-374, taf. xviii-xix. **91.1.**
2147. Heinz, R. Untersuchungen über den bau und die entwickelung der menschlichen placenta. Arch. f. gynäk., xxxiii, 413-442, taf. vi-vii. **88.1.**
2148. Hennig, C. Studien über den bau der menschlichen placenta und über ihr erkranken. Leipzig, 39 p., 8 pls. **72.1.**
2149. ——— Bemerkungen über den bau der placenta. Arch. f. gynäk., xiii, 307-308. **78.2.**
2150. Hicks, J. Braxton. Some remarks on the anatomy of the human placenta. Journ. anat. phys., vi, 405-410. **72.1.**
2151. Hofmeier, M. Zur anatomie der placenta. Centralbl. f. gynäk., xiii, 538. Arch. f. gynäk., xxxv, 521. **89.1.**
2152. ——— Die menschliche placenta; beiträge zur normalen und pathologischen anatomie derselben. Wiesbaden, 168 p., 10 pls. 8vo. **90.1.**
2153. Holl, M. Ueber die blutgefässe der menschlichen nachgeburt. Sitzb. Wien. akad., lxxxiii, abth. 3, 1-41, taf. i-ii. **81.1.**
2154. Hollard, H. Sur le placenta des rongeurs et en particulier sur celui des lapins. Ann. sc. nat., sér. 4, xix, 223-232, pl. i. **63.1.**
2155. Homburger. Die nachträgliche diagnose der lagerung des eies im uterus aus den ausgestossenen nachgeburtstheilen. Freund gynäk. klinik, i, 663-676. **85.1.**
2156. Home, Sir Everard. On the placenta. Phil. trans. roy. soc. Lond., cxii, 401-407, pls. xlii-xlviii. **22.1.**
2157. ——— On the existence of nerves in the placenta. Phil. trans. roy. soc. Lond., 66-80, pls. ii-iv. **25.1.**
2158. Hubrecht, A. A. W. Keimblätterbildung und placentation des igels. Anat. anz., iii, 510-515. **88.1.**
2159. ——— Studies in mammalian embryology; 1. The placentation of Erinaceus europaeus, with remarks on the phylogeny of the placenta. Q. J. M. S., xxx, 283-404, pls. xv-xxvii. **89.1.**
2160. Hyrtl, J. Die blutgefässe der menschlichen nachgeburt in normalen und abnormen verhältnissen. Wien, viii, 152 p., 20 pls. 4to. **70.1.**
2161. Jassinsky, P. Zur lehre über die structur der placenta. Virchow's Arch., xl, 341-352, taf. iii. **67.1.**
2162. Joly, N. Études sur le placenta de l'ai (Bradypus tridactylus Linn.); place que cet animale occupe dans la série des mammifères. C. R. acad. sc. Paris, lxxxvii, 283-287. **78.1.**
2163. Kastschenko, N. Das menschliche chorionepithel und dessen rolle bei der histogenese der placenta. His's Arch., 451-480, taf. xxi. **85.1.** (Also in Russian, Charkow, 33 p., pls. i-ii, 1884.)
2164. Keibel, Franz. Zur entwicklungsgeschichte der menschlichen placenta. Anat. anz., iv, 537-539. **89.2.**
2165. Klebs, E. Zur vergleichenden anatomie der placenta. Arch. f. mikr. anat., xxxvii, 335-356, taf. xvii. **91.1.**
2166. Klein, G. Ueber die entstehung der placenta marginata. Arch. f. gynäk., xxxvi, 525-526. **89.1.**
2167. Kölliker, A. Ueber die placenta der gattung Tragulus. Verh. phys.-med. ges. Würzburg, n. f. x, 74-83, taf. iv-v. **77.1.**
2168. Koubassoff. Passage des microbes pathogènes de la mère au foetus. C. R. acad. sc. Paris, ci, 101-104. **85.1.**
2169. Langhans, Th. Zur kenntniss der menschlichen placenta. Arch. f. gynäk., i, 317-334, taf. v. **70.1.**
2170. ——— Untersuchungen über die menschliche placenta. His's Arch., 188-267, taf. vii-viii. **77.1.**
2171. ——— Ueber die zellschicht des menschlichen chorion. Beiträge zur anat. und embryologie: festgabe, F. G. J. Henle, 69-79, taf. ixA. **82.1.**
2172. Laulanié. Sur la nature de la néoformation placentaire et l'unité de composition du placenta. C. R. acad. sc. Paris, c, 651-653. **85.1.**
2173. ——— Sur la processus vaso-formatif qui préside à l'édification de la zone fonctionnelle du placenta maternel dans le cobaye. C. R. soc. biol. Paris, sér. 8, iii, 506-509. **86.1.**
2174. ——— Sur une nouvelle espèce d'élément anatomique: la cellule placentaire de quelques rongeurs. C. R. soc. biol. Paris, sér. 8, ii, 130-132. **85.2.**
2175. Lee, Robert. On the structure of the human placenta and its connection with the uterus. Phil. trans. roy. soc. Lond., cxxii, 57-66, pls. i-ii. **32.1.**
2176. Leopold, G. Ueber den bau der placenta. Arch. f. gynäk., xxxv, 520. **89.1.**
2177. Lieberkühn, N. Der grüne saum der hundeplacenta. Arch. f. anat. u. phys., anat. abth., 196-212, taf. xiii. **89.1** Abstract: Sitzb. Marburg. ges., 1887, 22.

2178. Lombardini, L. Sulla placenta. Giorn. anat. fis. pat., Pisa, xxi, 253-271. **89.1**.
2179. Lüsebrink, F. W. Die erste entwickelung der zotten in der hunde-placenta. Anat. hefte, ii, abth. 1, 163-185, taf. xix-xx. **92.1**.
2180. Marcy, H. O. The placental development in mammals; A unity of anatomical and physiological modality in all vertebrates. Ann. anat. and surg. **82.1**.
2181. Masius, Jean. De la genèse du placenta chez le lapin. Arch. de biol., ix, 83-118, taf. v-viii. **89.1**.
2182. Masquelin, H., *and* Swaen, A. Premières phases du développement du placenta maternel chez le lapin. Arch. de biol., i, 25-44. **80.1**.
2183. Manthner, J. Ueber den mütterlichen kreislauf in der kaninchenplacenta mit rücksicht auf die in der menschenplacenta bis jetzt vorgefundenen anatomischen verhältnisse. Sitzb. Wien. akad., lxvii, abth. 3, 118-124, taf. i. **73.1**.
2184. Meyer, L. Ueber die blutmenge der placenta. Centralbl. f. gynäk., li, 220-222. **78.1**.
2185. Minot, C. S. Bemerkungen zu dem Schröder'schen uteruswerke. Anat. anz., ii, 19-22. **87.94**
2186. ——— Die placenta des kaninchens. Biol. centralbl., x, 114-122. **90.116**.
2187. ——— A theory of the structure of the placenta. Anat. anz., vi, 125-131. **91.126**.
2188. Mochnatscheff. Ueber die beziehung zwischen der schwangeren gebärmutter und der zahl der farblosen zellen im blute, das dieselbe durchströmt. Arch. f. gynäk., xxxvi, 277-288. **89.1**.
2189. Mogilowa, Anna Reinstein. Ueber die betheiligung der zellschicht des chorion an der bildung der serotina und reflexa. Virchow's Arch., cxxiv, 522-545, taf. ix. **91.1**.
2190. Morawski, F. Zur anatomie der menschlichen placenta. Würzburg, 35 p., 8vo. (Inaug. diss.) Königsberg. **89.1**.
2191. Omitted.
2192. Nitabuch, Raissa. Beiträge zur kenntniss der menschlichen placenta. Bern. 39 p., 1 pl. (Diss.) **87.1**.
2193. Nusbaum, Jozef. Zur entwickelungsgeschichte der placenta bei der maus (weisse varietät). Anat. anz., v, 233-236. **90.2**
2194. Orth, J. Das wachsthum der placenta foetalis und Boll's prinzip des wachsthums. Zeitschr. f. geburtsh. u. gynäk., ii, 9-23, taf. iii. **78.1**.
2195. Prenant, A. La morphologie du placenta. Semaine méd., x, 361-365. **90.2**.
2196. Pyle, J. P. An experimental research on the utero-placental circulation. Philadelphia med. times, xiv, 711-715. **84.1**.
2197. Reid. On the anatomical relations of the blood-vessels of the mother to those of the foetus in the human species. Edinb. med. surg. journ., lv, 1-12, pl. i; appendix, *ibid.*, 135-136. **41.1**.
2198. Reitz. Beiträge zur kenntniss des baues der placenta des weibes. Sitzb. Wien. akad., lvii, 1009-1012, taf. i. **68.1**.
2199. ——— Placenta. Stricker's Handb. d. gewebelehre, ii, 1183-1186. **72.1**.
2200. Ribemont-Dessaignes, A. Des placentas multiples dans les grossesses simples. Ann. de gynéc., xxvii, 12-52. **87.1**.
2201. Ritgen, F. A. Beiträge zur aufhellung der verbindung der menschlichen frucht mit dem fruchthälter und der ernährung derselben. Leipzig u. Stuttgart, 78 p., 3 pls. fol. **35.1**.
2202. Robin, Ch. Recherches sur les modifications graduelles des villosités du chorion et du placenta. Mém. soc. biol. Paris, sér. 2, i, 63-75. **54.1**.
2203. ——— Note sur les connexions anatomiques et physiologiques du placenta avec l'utérus. C. R. soc. biol. Paris, 34-41. **57.1**.
2204. Rohr, Karl. Die beziehungen der mütterlichen gefässe zu den intervillösen räumen der reifen placenta, speciell zu r thrombose derselben ("weisser infarct"). Virchow's Arch., cxv, 505-534, taf. xiv. **89.1**.
2205. Rolleston. On the placental structures of the tenrec (Centetes ecaudatus) and of those of certain other Mammalia, with remarks on the value of the placental system of classification. Trans. zool. soc. Lond., v, 285-316, pl. i. **66.1**.
2206. Romiti, G. Sulla struttura e sviluppo della placenta. [Rabbit.] Riv. clin. Bologna, ser. 2, iii, 5-10. **73.1**.
2207. ——— Sul distacco della placenta. Riv. clin. Bologna, ser. 2, vi, 79-82. **76.1**.
2208. ——— Placenta (anatomia descriptiva e struttura). Encicl. med. ital., ser. 2, iii, parte 3. **87.1**.
2209. Ruge, C. Ueber die placenta. Arch. f. gynäk., xxix, 342. **87.1**.
2210. Ryder, J. A. The placentation of the two-toed ant-eater Cycloturus didactylus. Proc. acad. nat. sc. Philadelphia, 115-120. **87.3**.
2211. ——— The vestiges of a zonary decidua in the mouse. Am. nat., xxi, 1037-1038. **87.5**
2212. ——— A theory of the origin of placental types and on certain vestigiary structures in the placentae of the mouse, rat, and field mouse. Am. nat., xxi, 780-784. **87.6**.
2213. Schatz, F. Die gefässverbindungen der placentakreisläufe einiger zwillinge, ihre entwicklung und ihre folgen. Arch. f. gynäk., xxiv, 337-399, taf. i-v. **84.1**.
2214. ——— Die gefässverbindungen der placentakreisläufe einiger zwillinge, etc. Arch. f. gynäk., xxvii, 1-72, taf. i-iv. **85.1**.
2215. ——— Die gefässverbindungen der placentakreisläufe einiger zwillinge, ihre entwicklung und ihre folgen. (Fortsetzung.) Arch. f. gynäk., xxix, 419-443. **87.1**. Abstract: München. med. wochenschr. **88.1**.
2216. Schroeder van der Kolk, J. L. C. Waarnemingen over het maaksel van de menschelijke placenta en over haren bloeds-omloop. Verh. 1ste kl. nederl. inst. Amsterdam, R. 3, iv, 69-180, taf. i-vi. **51.1**.

2217. Schultze, B. S. Die placentarrespiration des foetus. Jen. zeitschr. f. med. u. naturw., iv, 511-552. **68.1.**
2218. Selenka, E. Zur entstehung der placenta des menschen. Biol. centralbl., x, 737-742. **91.1.**
2219. Strahl, H. Ueber den bau der placenta. Sitzb. Marburg. ges., 159-166. **88.4.**
2220. ——— Untersuchungen über den bau der placenta; i. Die anlagerung des eies an die uteruswand. Arch. f. anat. u. phys., anat. abth., 213-230, taf. xiv. **89.1.**
2221. ——— Untersuchungen über den bau der placenta, i; fortsetzung. Arch. f. anat. u. phys., anat. abth., suppl., 197-212, taf. vii. **89.4.**
2222. ——— Ueber die placenta von Putorius furo. Anat anz., iv, 375-377. **89.2.**
2223. ——— Zur vergleichenden anatomie der placenta. Verh. anat. ges. Berlin, iii, 15-16. **89.5.**
2224. ——— Untersuchungen über den bau der placenta; iii. Der bau der hundeplacenta. Arch. f. anat. u. phys., anat. abth., 185-203, taf. ix-x. **90.1.**
2225. ——— Ueber den bau der placenta von Talpa europaea und über placentardrüsen. Anat. anz., v, 362-366. **90.3.**
2226. ——— Untersuchungen über den bau der placenta; iv. Die histologischen veränderungen der uterusepithelien in der raubthierplacenta. Arch. f. anat. u. phys., anat. abth., suppl., 118-134, taf. vi-vii. **90.4.**
2227. ——— Ueber umwandlung einer gürtelformig angelegten in eine doppeltscheibenförmige placenta. Verh. anat. ges., v, 121-124. **91.1.**
2228. ——— Untersuchungen über den bau der placenta; v. Die placenta von Talpa europaea. Anat. hefte, ii, abth. 1, 115-161, taf. xiii-xviii. **92.1.**
2229. Omitted.
2230. Sym, A. C. On a case of vesicular placenta from a premature birth at the seventh month, the child being born alive. Edinb. med. journ., xxxiii, 102-109. **87.1.**
2231. Tafani, A. La circolazione nella placenta di alcuni mammiferi. Lo sperimentale, lvi, 158-165. **85.1.** (For translation see no. 2233.)
2232. ——— Sulle condizione uteroplacentari della vità fetale. Arch. scuola anat. pat. diretto dal Pellizari, Firenze, iv, 53-216, tab. i-viii. **86.1.**
2233. ——— La circulation dans le placenta de quelques mammifères. Arch. ital. biol., viii, 49-57. **87.1.** (A translation of no. 2231.)
2234. Turner, Wm. De la placentation des cétacés comparée à celle des autres mammifères. Journ. zool., i, 304-323, pl. xvi. **72.2.**
2235. ——— Observations on the structure of the human placenta. Journ. anat. phys., ser. 2, vi, 120-133, pl. v. **73.1.**
2236. ——— On the placentation of the sloths (Choloepus hoffmanni). Trans. roy. soc. Edinb., xxvii, 71-104, pl. iii-vi. **73.2.**
2237. ——— On the placentation of seals (Halichoerus gryphus). Trans. roy. soc. Edinb., xxvii, 275-304, pls. xviii-xxi. **75.1.**
2238. ——— Lectures on the comparative anatomy of the placenta; first series. Edinburg, 124 p., 3 pls. **76.1.**
2239. ——— Note on the placentation of Hyrax. Proc. roy. soc. Lond., xxiv, 151-155. **76.2.**
2240. ——— On the placentation of the lemurs. Phil. trans. roy. soc. Lond., clxvi, 569-587, pl. xlix-li. Abstract: Proc. roy. soc., xxiv, 409. **76.3.** (See no. 2243.)
2241. ——— On the placentation of the Cape ant-eater (Orycteropus capensis). Journ. anat. phys., x, 693-706. **76.4.**
2242. ——— Some general observations on the placenta, with especial reference to the theory of evolution. Journ. anat. phys., xi, 33-53. **77.1.**
2243. ——— On the placentation of the lemurs. Journ. anat. phys., xii, 147-153. **77.2.** (See no. 2240.)
2244. ——— A further contribution to the placentation of the Cetacea (Monodon monoceros). Proc. roy. soc. Edinb., ix, 103-110. **77.3.**
2245. ——— On the placentation of the apes, with a comparison of the structure of their placenta with that of the human female. Phil. trans. roy. soc. Lond., lxix, 523-562, pls. xlviii-xlix. **79.1.**
2246. ——— On the cotyledonary and diffused placenta of the Mexican deer (Cervus mexicanus). Journ. anat. phys., xiii, 195-200. **79.3.**
2247. ——— On the placenta of the bog-deer (Cervus porcinus). Journ. anat. phys., xiii, 94-98. **79.4.**
2248. ——— An additional contribution to the placentation of lemurs. Proc. roy. soc. Lond., xliv, 277-282 **88.1.**
2249. ——— On the placentation of Halicore dugong. Trans. roy. soc. Edinb., xxxv, 641-662, pl. i-iii. **89.1.**
2250. Virchow, Rudolph. Ueber die bildung der placenta. Verh. phys.-med. ges. Würzburg, iv, 370-382. **54.1.**
2251. Waldeyer, W. Ueber den placentarkreislauf des menschen. Sitzb. akad. wiss. Berlin, vi, 83-93. **87.1.**
2252. ——— Bemerkungen über den bau der menschen- und affen-placenta. Arch. f. mikr. anat., xxxv, 1-51, taf. i-ii. **90.1.**
2253. Watson, M. On the female organs and placentation of the racoon (Procyon lotor). Proc. roy. soc. Lond., xxxii, 272-298, pls. iii-vi. Abstract: *ibid.*, xxxi, 325-326. **81.1.**
2254. Weldon, W. F. R. Note on the placentation of Tetraceros quadricornis. Proc. zool. soc. Lond., 2-6. **84.1.**
2255. Winkler, F. N. Zur kenntniss der menschlichen placenta. Arch. f. gynäk., iv, 238-265, taf. v. **72.1.**
2256. Young, A. H. On some recent observations on the development and structure of the placenta. Med. chron. Montreal, xiv, 262-266. **91.1.**

2257. Zarmella, E. Sul diverso luogo d' inserzione placentare e della sua importanza sull' andamento del parto e sullo sviluppo del neonato. Rivista sc. med. Venezia, ix, 448-451. **88.1**.

PREGNANCY.

2258. Duncan, J. Matthews. On the duration of pregnancy and the calculation of the date of confinement. Is Dr. Wm. Harvey or Dr. Wm. Montgomery in the right? Edinb. med. journ., ii, 410-415. **56.1**.
2259. Laniot, M. De la situation des foetus et de la disposition des oeufs dans les cas de grossesse gémellaire. Paris, 143 p. 4to. (Thèse.) **88.1**.
2260. Loewenhardt. Die berechnung und die dauer der schwangerschaft. Arch. f. gynäk., iii, 456-491. **72.1**.
2261. Meyer, P. J. Untersuchungen über die veränderungen des blutes in der schwangerschaft. Arch. f. gynäk., Berlin, xxxi, 145-160. **87.1**.
2262. Siexinger, J. von. Gefrierdurchschnitt einer kreissender. Tübingen. 3 pl. imp. fol. **88.1**.
2263. Sutton, J. Bland. The glands of the Fallopian tubes and their function. Brit. med. journ., 1010-1011. **88.1**.
2264. Werth. Beiträge zur anatomie und zur operativen behandlung der extrauterinschwangerschaft. Stuttgart, vii. 163 p. 1 pl. **87.1**.
2265. Winter, G. Zwei medianschnitte durch gebärende; eine anatomische studie. Berlin. 32 p. 8vo. **89.1**.

PROAMNION.

2266. Ravn, Edvard. Bemerkungen über die mesodermfreie zone in der keimscheibe der eidechsen. Anat. anz., iv, 155-160. **89.1**.
2267. Shore, T. W., *and* Pickering, J. W. The proamnion and amnion in the chick. Journ. of anat., xxiv, 1-22. **89.1**.

PROTOPLASM.

2268. Bütschli, O. Ueber die struktur des protoplasmas. Verh. naturhist.-med. ver. Heidelberg, n. f. iv, 423-434. **89.2**.
2269. ——— Weitere mittheilungen über die structur des protoplasmas. Verh. naturhist.-med. ver. Heidelberg, n. f. iv, 490-502. **90.1**.
2270. ——— Ueber die structur des protoplasmas. Verh. deutsch. zool. ges., 13-29. **91.1**.
2271. Frommann, C. Ueber neuere erklärungsversuche der protoplasmaströmungen und über die schaumstrukturen Bütschli's. Anat. anz., v, 661-672. **90.1**.
2272. Hanstein, Johannes v. Das protoplasma als träger der pflanzlichen und thierischen lebensverrichtungen. Sammlung von vorträgen f. d. deutsche volk, ii, 127-312. **87.1**.
2273. Kühne, W. Untersuchungen über das protoplasma und die contractilität. Leipzig, 158 p., 8 pls. **64.1**.
2274. Schäfer, E. A. On the structure of amoeboid protoplasm, with a comparison between the nature of the contractile process in amoeboid cells and in muscular tissue and a suggestion regarding the mechanism of ciliary action. Proc. roy. soc. Lond., xlix, 193-198. **91.1**.
2275. Schultze, Max. Das protoplasma der rhizopoden und der pflanzenzellen. Leipzig, 68 p. **63.1**.
2276. Schwarz, F. Die morphologische und chemische zusammensetzung des protoplasmas. Beitr. z. biol. d. pflanz., Breslau, v, i-viii, 1-244, pls. i-viii. **87.1**.

REPTILES.

2277. Baer, K. E. von. Beitrag zur entwickelungsgeschichte der schildkröten. Müller's Arch., 544-550, taf. xi, fig. 17-18. **34.2**.
2278. Balfour, F. M. On the early development of Lacertilia together with some observations on the nature and relations of the primitive streak. Q. J. M. S., xix, 421-430, pl. xix. **79.1**.
2279. Clark, H. J. Embryology of the turtle. Agassiz's Contrib. nat. hist. U. S., ii, 451-643, pl. i-xxvii. **57.1**.
2280. Clarke, S. F. The habits and embryology of the American alligator. Journ. morph., v, 181-214. **91.1**.
2281. Emmert, *and* Hochstetter. Untersuchung über die entwickelung der eidechsen in ihren eiern. Arch. f. d. phys., Halle, 84-122. **11.1**.
2282. Giacomini, E Materiali per la storia dello sviluppo del Seps chalcides (Cuv.) Bonap. Monitore zool. ital., ii, 179-192; 198-211, tav. iii. Abstract: Anat. anz., vi, 548-551. **91.1**
2283. Hoffmann, C. K. Contribution à l'histoire du développement des reptiles. Arch. néerland., xvii, 168-192, pls. iv-v. **82.2**.
2284. ——— Beiträge zur entwicklungsgeschichte der reptilien. Zeitschr. wiss. zool., xl, 214-246, taf. xiii-xiv. **84.3**.
2285. ——— Weitere untersuchungen zur entwicklungsgeschichte der reptilien. Morph. jahrb., xi, 176-219, taf. x. **85.1**

2286. Junglöw, V. H. Ueber einige entwickelungsvorgänge bei reptilien-embryonen. Anat. hefte, ii, abth. 1, 187-204, taf. xxi. **92.1**

2287. Kupffer, C., *and* Benecke, B. Die ersten entwicklungsvorgänge am ei der reptilien. Königsberg. 11 p. **78.2**.

2288. Mitsukuri, K., *and* Ishikawa, C. On the formation of the germinal layers in Chelonia. Q. J. M. S., xxvii, 17-48, pls. ii-v. Journ. coll. sc. Japan, i, 211-246, 4 pls. **87.1**.

2289. Orr, Henry. Contributions to the embryology of the lizard; with especial reference to the central nervous system and some organs of the head; together with observations on the origin of the vertebrates. Journ. morph., i 311-364, pls. xii-xvi. **87.1**.

2290 Ostroumoff, A. Zur entwickelungsgeschichte der eidechsen. Zool. anz., xi, 620-622. **88.1**.

2291 Parker, W. H Report on the development of the green turtle (Chelone viridis, Schneid.). Challenger rep , zool , i, pt. v, 58 p. pls. i-xiii. Abstracts: Nature, xix, 593-594. Proc. roy. soc. Lond., xxviii, 329-346. **80.1**.

2292. Perényi, J. Entwicklung des amnion, Wolff'schen ganges und der allantois bei den reptilien. Zool. anz., xi, 138-141. **88.1**.

2293 ——— Amnion und Wolff'scher gang der eidechsen. Math. u. naturw. berichte aus Ungarn, vi, 14-26. **88.2**.

2294. Rathke, H. Entwicklungsgeschichte der natter (Coluber natrix). Königsberg, iv, 232 p., taf. i-vii. 4to. **39.1**.

2295. ——— Ueber die entwickelung der schildkröten. Braunschweig, xvi, 267 p., 10 pls. 4to. **48.1**.

2296. Strahl, H. Ueber den primitivstreifen der eidechse. Sitzb. Marburg. ges., 49-51. **81.2**

2297. ——— Beiträge zur entwicklung von Lacerta agilis. Arch. f. anat u. phys., anat. abth., 242-278, taf. xiv-xv. **82.1**.

2298. ——— Ueber den gefässhof von Lacerta agilis. Sitzb. Marburg. ges., 72-73. **82.3**.

2299. ——— Ueber die entwicklung von Lacerta agilis, vivipara und viridis. Sitzb. Marburg. ges., 61-62. **82.4**.

2300. ——— Beiträge zur entwickelung der reptilien. Arch. f. anat. u. phys., anat. abth., 1-43, taf. i. **83.1**.

2301. ——— Die entwicklungsvorgänge am vorderen ende der embryonen von Lacerta agilis und vivipara. Zool. anz., vi, 17-19. **83.3**.

2302. ——— Ueber frühe entwicklungsstadien von Lacerta agilis. Zool. anz., vi, 347-350. **83.4**.

2303. ——— Ueber entwicklungsvorgänge am vorderende des embryo von Lacerta agilis. Arch. f. anat. u. phys., anat. abth., 41-88, taf. iii-iv. **84.1**.

2304. ——— Ueber wachsthumsvorgänge an embryonen von Lacerta agilis. Abh. Senckenb. naturf. ges., xiii, 409-473, taf. i-v. **84.2**.

2305. Voeltzkow, A. On the oviposition and embryonic development of the crocodile. Ann. mag. nat. hist., ser. 6, ix, 66-72 **92.1**.

2306. Weldon, W. F. R. Note on the early development of Lacerta muralis. Q. J. M. S., xxiii, 134-144, pls. iv-vi. **83.1**.

2307 Wenckebach, K. F. Der gastrulationsprozess bei Lacerta agilis Anat. anz., vi, 57-61, 72-77 **91.1**.

2308. Will, L. Bericht über studien zur entwickelungsgeschichte von Platydactylus mauritanicus. Sitzb. preuss. akad. wiss. Berlin, iii, 1121-1128. **89.1**.

2309. ——— Zur entwicklungsgeschichte des gecko's. Biol. centralbl., x, 592-600. **90.1**.

2310. ——— Zur kenntnis der schildkröten-gastrula. Biol. centralbl., xii, 182-192. **92.1**.

SALIVARY GLANDS.

2311. Chievitz, J. H. Beiträge zur entwicklungsgeschichte der speicheldrüsen. Arch f anat. u. phys., anat. abth., 401-436, taf. xix. **85.1**.

2312. Giacomini, E. Sulle-glandule salivari degli uccelli. Monitore zool. ital., i, 158-163, 176-188, 195-211, tav. i. **90.1**.

SEGMENTATION OF BODY.

2313. Ahlborn, F. Ueber die segmentation des wirbelthierkörpers. Z. Z., xl, 309-330. **84.2**.

2314. Caldwell, W. H. Blastopore, mesoderm and metameric segmentation. Q. J. M. S., xxv, 15-28, pl. ii. **85.1**.

2315. Meyer, Eduard. Die abstammung der anneliden; der ursprung der metamerie und die bedeutung des mesoderms. Biol. centralbl., x, 296-308. **90.1**.

2316. Platt, Julia B Studies on the primitive axial segmentation of the chick. Bull. mus. comp. zool., xvii, 171-190, pl. i-ii. **89.1**.

2317. Rabl, Carl. Ueber die metamerie des wirbelthierkopfes. Verh. anat. ges. Wien, vi, 104-135. **92.1**.

2318. Sedgwick, A. On the origin of metameric segmentation and some other morphological questions. Q. J. M. S., xxiv, 43-82, pls. i-ii. **84.1**.

SEGMENTATION OF OVUM.

2319. Bambeke, C. van. Nouvelles recherches sur l'embryologie des batraciens; i. Enveloppes ovulaires, etc. ii. Fractionnement de l'oeuf, etc. Arch. de biol., i, 305-380, pls. xi-xiv. **80.1**.

2320. Bellonci, J. La cariocinèse dans la segmentation de l'oeuf de l'axolotl. Arch. ital. biol., vi, 52-57, pl. i. *Translated from* Accad. lincei., mem. xix. **84.2**.

2321. Beneden, E. van, *and* Julin, C. La segmentation chez les ascidiens dans ses rapports avec l'organisation de la larve. Arch. de biol., v, 111-126, pls. vii-viii. Bull. acad. Belg., sér. 3, vii, 431-447, pls. i-ii. **84.6**.

2322. Bergmann. Die zerklüftung und zellenbildung im froschdotter. Müller's Arch., 89-102. **41.1**.

2323. ——— Zur verständigung über die dotterzelleubildung. Müller's Arch., 92-101. **42.1**.

2324. Born, G. Ueber den einfluss der schwere auf das froschei. Bresl. ärztl. zeitschr., vi, 185-189. **84.3**

2325. Boveri, T. Ueber den anteil des spermatozoön an der teilung des eies. Sitzb. ges. morph. München, iii, 151-164. **87.1**.

2326. Brooks, W. K. Alternation of periods of rest with periods of activity in the segmenting eggs of vertebrates. Stud. biol. lab. Johns Hopkins univ., ii, 117-118, pl. viii. **81.1**.

2327. Driesch, Hans. Entwicklungsmechanische studien; i. Der werth der beiden ersten furchungszellen in der echinodermen-entwickelung; experimentelle erzeugung von theil- und doppelbildungen. ii. Ueber die beziehungen des lichtes zur ersten etappe der thierischen formbildung. Zeitschr. wiss. zool., liii, 160-184, taf. vii. **91.1**.

2328. Fol, H. Die erste entwickelung des geryonideneies. Jen. zeitschr. f. naturw., vii, 471-492, taf. xxiv-xxv. **73.1**.

2329. Frommann, C. Beiträge zur kenntniss der lebensvorgänge in tierischen zellen. Jen. zeitschr. f. naturw., xxiii, 389-412, taf. xxiv. **89.1**.

2330. Fusari, R. La segmentazioue nelle uova dei teleostei. Atti XII congress. assoc. med. ital. Pavia, i, 179. **87.1**.

2331. Gerbe, M. Z. Recherches sur la segmentation de la cicatricule et la formation des produits adventifs de l'oeuf des plagiostomes et particulièrement des raies. Journ. anat. et phys., viii, 609-616, pls. xx-xxii. **72.1**.

2332. Hertwig, O. Welchen einfluss übt die schwerkraft auf die theilung der zellen. Jen. zeitschr. f. naturw., xviii, 175-205, taf. ix. *Reprinted:* Untersuch. morph. u. phys. der zelle, h. ii. **84.1**.

2333. Kölliker, A. von. Zur lehre von den furchungen. Wiegmann's Arch. f. naturgesch., jahrg. 13, bd. i, 9-22. **47.1**.

2334. ——— Das äquivalent der attraktionssphären E. v. Beneden's bei Siredon. Anat. anz., iv, 147-155. **89.1**.

2335. ——— Ueber die mitosen sich furchender eier des Axolotl. München. med. wochenschr., xxxvi, 69. **89.2**.

2336. Leydig, Fr. Die dotterfurchung nach ihrem vorkommen in der theirwelt und nach ihrer bedeutung. Oken, Isis, 161-193. **48.1**.

2337. Miescher, F. Die kerngebilde im dotter des huhnereies. Hoppe-Seyler's Med. chem. untersuch., 502-509. **71.1**.

2338. Minot, C. S. Segmentation of the ovum with especial reference to the Mammalia. Am. nat., xxiii, 463-482, 753-769. **89.113**.

2339. Oellacher, J. Untersuchungen über die furchung und blätterbildung im hühnereie. Stud. inst. exper. pathol. Wien, 54-73, taf. i. **70.1**.

2340. Owsjannikow, Ph. Ueber die ersten vorgänge der entwickluug in den eiern des Coregonus lavaretus. Bull. acad. St. Pét., xix, 225-235, 1 taf. **74.1**.

2341. Pflüger, E. Ueber die parthenogenetische furchung der eier der amphibien. Pflüger's Arch., xxix, 40-44. **83.3**.

2342. ——— Ueber den einfluss der schwerkraft auf die theilung der zellen und auf die entwicklung des embryo. Pflüger's Arch., xxxi, 311-318; xxxii, 1-80, taf. i-ii. **83.6**.

2343. ——— Ueber die einwirkung der schwerkraft und anderer bedingungen auf die richtung der zelltheilung. Arch. f. ges. phys., xxxiv, 607-616. **84.1**.

2344. Platner, G. Die erste entwickelung befruchteter und parthenogenetischer eier von Liparis dispar. Biol. centralbl., viii, 521-524. **88.1**.

2345. Prévost, J. L., *and* Dumas, J. B. Développement de l'oeuf des batraciens. Ann. sc. nat., ii, 100-121, 129-149. **42.2**.

2346. Reichert, K. B. Der furchungsprozess und die sogenannte zellenbildung um inhaltsportionen. Müller's Arch., 196-282, taf. ix. **46.1**.

2347. ——— Der faltenkranz an den beiden ersten furchungskugeln des froschdotters und seine bedeutung für die lehre von der zelle. Müller's Arch., 133-136. **61.1**.

2348. Roux, W. Beiträge zur embryonalen entwickeluugsmechanik; ii. Ueber die entwicklung der froscheier bei aufhebung der richtenden wirkung der schwere. Bresl. ärztl. zeitschr. **84.1**.

2349. ——— Beiträge zur entwickelungsmechanik des embryo; iii. Ueber die bestimmung der hauptrichtungen des froschembryo im ei und über die erste theilung des froscheies. Bresl. ärztl. zeitschr., vii, 64, 73, 87, 100, 112, 125. **85.1**.

2350. ——— Beiträge zur entwickelungsmechanik des embryo; iv. Die richtungsbestimmung der medianebene des froschembryo durch die kopulationsrichtung des eikernes und des spermakernes. Arch. f. mikr. anat., xxix, 157-213, taf. x. **87.1**.

2351. ——— Zur frage der axenbestimmung des embryo im froschei. Biol. centralbl., viii, 399-413. **88.1**.

2351a. ——— Beiträge zur entwickelungsmechanik des embryo. Ueber die künstliche hervorbringung halber embryonen durch zerstörung einer der beiden ersten furchungskugeln, sowie über die nachentwickelung (postregeneration) der fehlenden körperhälfte. Virchow's Arch., cxiv, 113-154, 246-291, taf. ii-iii. **88.3, 4**.

2352. Ryder, J. A. On the nuclear cleavage-figures developed during the segmentation of the germinal disk of the egg of the salmon. Bull. U. S. fish comm., i, 335-339, pl. xviii. **81.1**

2353. Ryder, J. A. The law of nuclear displacement and its significance in embryology. Science, i, 273-277. **83.1.**
2354. Sarasin, C. F. Reifung und furchung der reptilieneier. Arb. zool. inst. Würzburg, vi, 159-216, taf. xii-xv. **83.1.**
2355. Schultze, M. J. S. Praecedunt observationes nonnullae de ovorum ranarum segmentatione quae "furchungsprocess" dicitur. Bonnae, 16 p., 2 pls, 4to. **63.2.**
2356. Schultze, O. Ueber axenbestimmung des froschembryo. Biol. centralbl., vii, 577-588. **87.2.**
2357. Watase, S. Studies on cephalopods; i. Cleavage of the ovum. Journ. morph., iv, 247-302, pls. ix-xii. **91.1.**

SEX.

2358. Berner, Hj. Ueber die ursachen der geschlechtsbildung; eine biologische studie. Christiania, 70 p. Biol. centralbl. iv, 461-465. **83.1.**
2359. Blackwell, A. B. The comparative longevity of the sexes. Proc. Am. assoc. adv. sc., xxxiii, 515-517. **84.1.**
2360. Boveri, Th. Ein geschlechtlich erzeugter organismus ohne mütterliche eigenschaften. Ges. f. morph. phys. München, 73-80. **89.1.**
2361. Düsing, K. Die factoren welche die sexualität entscheiden. Jena, 37 p. Diss. **83.1.**
2362. ——— Die regulierung des geschlechtsverhältnisses bei der vermehrung der menschen, thiere und pflanzen. Jen. zeitschr. f. naturw., xvii, 593-940. **84.1.**
2363. Funkhouser, R. Sex. Trans. med. assoc. St. Louis. xxviii, 139-145. **85.1.**
2364. Geddes, P. Theory of growth, reproduction, sex, and heredity. Proc. roy. soc. Edinb., xiii, 911-931. **86.2.**
2365. Geddes, P., *and* Thomson, J. A. The evolution of sex Biol. centralbl., x, 309-317. **90.1.**
2366. Giard, A. Sur les globules polaires et les homologues de ces éléments chez les infusoires ciliés. Bull. sc. France et Belg., xxii, 202-221. **90.1.**
2367. Goehlert, V. Die geschlechtsverschiedenheit der kinder in den ehen. Zeitschr. f. ethnologie, xiii, 117-129. **81.1.**
2368. Granville, J. Mortimer. A note on intention in the determination of sex, and the mental and physical inheritance of children. Lancet, ii, 650-652. **80.1.**
2369. Guignard, L. Sur la formation et la différentiation des éléments sexuels qui interviennent dans la fécondation. C. R. acad. sc. Paris, cx, 590-592. **90.1.**
2370. Hamann, Otto. Die urkeimzellen (ureier) im tierreich und ihre bedeutung. Jen. zeitschr. f. naturw., xxi, 516-538. **87.1.**
2371. Herz, G. Beitrag zur frage über die vorausbestimmung des geschlechts. Arch. f. wiss. u. prakt. thierheilk. Berlin, xvi, 84-99. **90.1.**
2372. Pflüger, E. Hat die concentration des samens einen einfluss auf das geschlecht? Pflüger's Arch., xxix, 1-12. **83.1.**
2373. ——— Ueber die das geschlecht bestimmenden ursachen und die geschlechtsverhältnisse der frösche. Pflüger's Arch., xxix, 13-40. **83.2.**
2374. Pott, Emil. Ueber neubildungen und individualpotenz; ein beitrag zur thierzuchtlehre. Graz in Steiermark, 96 p. (Inaug. diss.) **70.1.**
2375. Richarz. Bemerkungen über die ursachen der geschlechtsbildung. Fortschr. d. med. Berlin, iii, 722-723. **85.1.**
2376. Ryder, J. A. The origin of sex through cumulative integration, and the relation of sexuality to the genesis of species. Proc. Am. phil. soc., xxviii, 109-159. **90.1.**
2377. Sabatier, A. Quelques observations sur la constitution de l'oeuf et de ses enveloppes chez les chitonides. Trav. lab. zool. Montpellier, sér. 1, v, 101-110, pls. x-xi. **85.1.**
2378. Schlechter, Joh. Ueber die ursachen, welche das geschlecht bestimmen. Rev. f. thierheilk. u. thierarz. Wien. Abstract by Wilckens, Biol. centralbl., iv, 627-629; Fortschr. d. med., 1885, 415. **84.1.**
2379. Omitted.
2380. Wilckens, M. Untersuchung über das geschlechtsverhältniss und die ursachen der geschlechtsbildung bei hausthieren. Landwirth. jahrb. **86.1.**
2381. Yung, E. De l'influence de la nature des aliments sur la sexualité. C. R. acad. sc. Paris, xcii, 854-856. **81.1.**

SEXUALITY

2382. Auerbach, Leopold. Zur charakteristik von ei und samen. Berlin klin. wochenschr., xxviii, 908-909. **91.1.**
2383. ——— Ueber einen sexuellen gegensatz in der chromatophilie der männlichen und weiblichen geschlechtsprodukte. Arch. f. anat. u. phys., phys. abth., 533-535. **91.2.**
2384. Beneden, E. van. De la distinction originelle du testicule et de l'ovaire; caractère sexuel des deux feuillets primordiaux de l'embryon; hermaphrodisme morphologique de toute individualité animale; essai d'une théorie de la fécondation. Bull. acad. Belg., sér. 2, xxxvii, 530-595, pl. i-ii. **74.1.**
2385. Bourne, A. G. Recent researches upon the origin of the sexual cells in hydroids; a review. Q. J. M. S., xxiii, 617-622. **83.1.**
2386. Brutenbach, Wilhelm. Die entstehung der geschlechtlichen fortpflanzung; eine phylogenetische studie. Kosmos, viii, 248-257. **80.1.**

2387. Bütschli, O. Bedeutung der conjugation. Broun's Thierreich, i, 1636-1643. **89.9.**
2388. Hartog, M. M. Abstract of Maupas's Researches on multiplication and fertilisation in ciliate infusorians. Q. J. M. S., xxxii, 599-614. **91.1.**
2389. ——— Some problems of reproduction: a comparative study of gametogeny and protoplasmic senescence and rejuvenescence. Q. J. M. S., xxxiii, 1-79. **91.2.**
2390. Hatschek, B. Ueber die bedeutung der geschlechtlichen fortpflanzung. Prag. med. wochenschr., xii, 385-388. **87.1**
2391. ——— On the significance of sexual reproduction. Ann. mag. nat. hist., ser. 6, i, 163-164. **88.2.**
2392. Hoffmann, H. Ueber sexualität. Bot. zeit., xliii, 145-153; 161-169. **85.1.**
2393. Maupas, E. Le rajeunissement karyogamique chez les cillés. Arch. zool. expér., sér. 2, vii, 149-517, pls. ix-xxiii. **89.1.**
2394. Minot, C. S. Theorie der genoblasten. Biol. centralbl., ii, 365-367. **83 47.**
2395. Nussbaum Moritz. Zur differenzirung des geschlechts im thierreich. Arch. f. mikr. anat., xviii, 1-121, taf. i-iv. **80.1.**
2396. Sabatier, A. Sur les cellules du follicule de l'oeuf et sur la nature de la sexualité. C. R. institut Paris, xcvi, 1804-1806. Trav. lab. zool. Montpellier, sér. 1, v, 97-99. **83.1.**
2397. ——— Recherches sur l'oeuf des ascidiens. Trav. lab. zool. Montpellier, sér. 1, v, 39-96, pls. vi-ix. **83.2.**
2398. ——— Sur les cellules du follicule et les cellules granuleuses chez les tuniciers. Recueil zool. suisse, i, 423-458, pls. xxii-xxiii. Trav. lab. zool. Montpellier, sér. 1, v, 237-271, pls. xiv-xv. **84.1.**
2399. ——— Contribution à l'étude des globules polaires et des éléments éliminés de l'oeuf en général. (Théorie de la sexualité.) Rev. sc. nat., 127, pls. i-ii. **84.2.**
2400. ——— Recueil des mémoires sur la morphologie des éléments sexuels et sur la nature de la sexualité. Paris, 271 p., 15 pls. 4to. **86.1.**
2401. Omitted.
2402. Weismann, A. Die entstehung der sexualzellen bei den hydromedusen. Jena, 24 pls. Abstract by author, Biol. centralbl., iv, 12-31. Abstract by H. N. Moseley, Nature, xxix, 114-118. **84.2.**
2403. ——— Amphimixis, oder die vermischung der individuen. Jena, 176 p. 8vo. **91.1.**

SKELETON.

2404. Bardeleben, K. Ueber das episternum des menschen. Sitzb. med.- naturw.ges. Jena, 146. **79.1.**
2405. Baumüller, B. Ueber die letzten veränderungen des Meckel'schen knorpels. Z. Z., xxxii, 466-511, taf. xxix-xxx. **79.1.**
2406. Baur, G. Ueber die morphogenie der wirbelsäule der amnioten. Biol. centralbl., vi, 332-342, 353-363. **85.1.**
2407. ——— On the morphology of ribs. Am. nat., xxi, 942-945. **87.4.**
2408. ——— On the quadrate in the Mammalia. Q. J. M. S., xxviii, 169-180. **88 1.**
2409. ——— On intercalation of vertebrae. Journ. morph., iv, 331-336. **91.1.**
2410. ——— The pelvis of the Testudinata; with notes on the evolution of the pelvis in general. Journ. morph., iv, 345-360. **91.2.**
2411. ——— Der carpus der schildkröten. Anat. anz., vii, 206-211. **92.1.**
2412. Béclard. Ueber die osteose oder die bildung, das wachsthum und die altersabnahme der knochen des menschen. Meckel's Arch., vi, 405-446. **20.1.**
2413. Bruch, C. Ueber die entwickelung der clavicula und die farbe des blutes; brieflicbe mittheilung an A. Kölliker. Zeitschr. wiss. zool., iv, 371-376. **53.1.**
2414. Carlier, O. Beiträge zur entwicklungsgeschichte der wirbelsäule. Z. Z., xxv, suppl., 65-76, taf. iv. **76.1.**
2415. Cope, E. D. On the intercentrum of the terrestrial Vertebrata. Trans. Am. phil. soc., n. s. xvi, 243-253, 1 pl. **86.4.**
2416. ——— The mechanical cause of the development of the hard parts of the Mammalia. Journ. morph., iii, 137-290, pls. ix-xiv. Preliminary notice: Am. nat., xxiii, 71-73. **89.1.**
2417. Corning, H. K. Ueber die sogenannte neugliederung der wirbelsäule und über das schicksal der urwirbelsäule bei reptilien. Morph. jahrb., xvii, 611-622, taf. xxx. **91.1.**
2418. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; iv. Die entwicklung und differenzirung der kiemenbogen der selachier. v. Zur entstehung und differenzirung der visceralbogen bei Petromyzon planeri. vi. Die paarigen und unpaaren flossen der selachier. Mitth. zool. stat. Neapel, v, 102-195, taf. v-xi. **84.1.**
2419. Omitted.
2420. Emery, C. Recherches sur la morphologie du squelette des extrémités chez les vertébrés terrestres; preliminary notice. Arch. ital. biol., xiv, 421-430. **91.1.**
2421. Fick, A. E. Zur entwickelungsgeschichte der rippen und querfortsätze. Arch. f. anat. u. phys., anat. abth., 30-42. **79.1.**
2422. Froriep, A. Zur entwickelungsgeschichte der wirbelsäule, insbesondere des atlas und epistropheus und der occipitalregion; ii. Beobachtung an säugethierembryonen. Arch. f. anat. u. phys., anat. abth., 69-150, taf. i-iii. **86.1.** (Compare no. 2481.)

2423. Gegenbaur, C. Ueber bau und entwickelung der wirbelsäule bei amphibien überhaupt und beim frosche insbesondere. Abh. naturf. ges. Halle, vi, 179-194, fig. 2. **62.1.**

2424. ——— Ein fall von erblichen mangel der pars acromialis claviculae mit bemerkungen über die entwickelung der clavicula. Jen. zeitschr. f. naturw., i, 1-16. **64.2.**

2425. ——— Untersuchungen zur vergleichenden anatomie; i. Carpus und tarsus. ii. Schultergürtel der wirbelthiere. iii. Brustflosse der fische. Leipzig, viii, 127 p. 6 pls.; vi, 176 p. 9 pls. 4to. **65.4.**

2426. ——— Ueber die entwicklung der wirbelsäule des Lepidosteus mit vergleichend-anatomischen bemerkungen. Jen. zeitschr. f. naturw., iii, 359-420, taf. vii-ix. **67.1.**

2427. ——— Ueber primäre und secondäre knochenbildung mit besonderer beziehung auf die lehre von dem primordialcranium. Jen. zeitschr. f. naturw., iii, 54-73. **67.2.**

2428. ——— Ueber das skeletgewebe der cyclostomen. Jen. zeitschr. f. naturw., v, 43-53, taf. i **69.1.**

2429. ——— Zur bildungsgeschichte lumbosacraler übergangswirbel. Jen. zeitschr f. naturw., vii, 438-440. **73.3.**

2430. ——— Die metamerie des kopfes und die wirbeltheorie des kopfskeletes, im lichte der neueren untersuchungen geprüft. Morph. jahrb., xiii, 1-114. **87.1.**

2431. Götte, A. Beiträge zur vergleichenden morphologie des skeletsystems der wirbelthiere; i. Brustbein und schultergürtel. Arch. f. mikr. anat., xiv, 502-620, taf. xxx-xxxiii. **77.1.**

2432. ——— Beiträge zur vergleichenden morphologie des skeletsystems der wirbelthiere; ii. Die wirbelsäule und ihre anhänge. Arch. f. mikr. anat., xv, 315-340, 442-541, taf. xx, xxviii-xxxiii. **78.2.**

2433. ——— Beiträge zur vergleichenden morphologie des skeletsystems der wirbelthiere; ii. Die wirbelsäule und ihre anhänge. Arch. f. mikr. anat., xvi, 117-152, taf. vii-ix. **79.1.**

2434. Grassi, B. Développement de la colonne vertébrale chez les poissons osseux; pt. I. Arch. ital. biol., iv, 236-244. **83.1.**

2435. Omitted.

2436. Hasse, C. Die entwicklung des atlas und epistropheus des menschen und der säugethiere. Anat. studien, i, 542-568, taf. xxv. Leipzig, 1 taf. **73.1.**

2437. Hasse, C., *and* Born, G. Bemerkungen über die morphologie der rippen. Zool. anz., ii, 81-84. **79.2.**

2438. Hasse, C., *and* Schwarck, W. Studien zur vergleichenden anatomie der wirbelsäule, insbesondere des menschen und der säugethiere. Hasse's Anat. studien, i, 21-171, taf. iv-vii. **70.1.**

2439. Hatschek, B. Die rippen der wirbeltiere. Verh. anat. ges., Berlin, iii, 113-120. **89.2.**

2440. Hertwig, O. Ueber bau und entwickelung der placoidschuppen und der zähne der selachier. Jen. zeitschr. f. naturw., vii, 331-404, taf. xii-xiii. **74.1.**

2441. ——— Ueber das hautskelet der fische. Morph. jahrb., ii, 328-395, taf. xxiii-xxviii. **76.1.**

2442. ——— Ueber das hautskelet der fische (Lepidosteus u. Polypterus). Morph. jahrb., v, 1-19, taf. i-iii. **79.1.**

2443. Omitted.

2444. Hoffmann, C. K. Beiträge zur vergleichenden anatomie der wirbelthiere. Niederländ. arch. f. zool., v, 19-112, taf. ii-ix. **80.1.**

2445. Huxley, T. H. The characters of the pelvis in the Mammalia and the conclusions respecting the origin of mammals, which may be based on them. Proc. roy. soc. Lond., xxviii, 395-405, pl. viii. **79.1.**

2446. Iversen, M. Bemerkungen über die dorsalen wurzeln des nervus hypoglossus. Ber. naturf. ges. Freiburg i. B., ii (1887), 33-36. **86.1.**

2447. Kaczander, J. Beitrag zur lehre über die entwicklungsgeschichte der patella. Med. jahrb., Wien, n. f. i, 59-78, taf. i. **86.1.**

2448. Kölliker, A. Weitere beobachtungen über die wirbel der selachier insbesondere über die wirbel der plagiostomen. Abh. senck. naturf. ges. Frankfurt, v, 51-99, taf. xiii-xvii. **65.1.**

2449. Lachi, Pilade. Il significato morfologico della colonna vertebrale umana. Arch. scuola anat. pat. dir. Pellizzari, Firenze, iv, 1-52. **86.1.**

2450. Mehnert, Ernst. Untersuchungen über die entwickelung des beckengürtels der Emys lutaria taurica. Morph. jahrb., xvi, 537-571, taf. xx. **90.1.**

2451. ——— Untersuchungen über die entwicklung des beckengürtels, bei einigen säugethieren. Morph. jahrb., xv, 97-112, taf. vi. **89.1.**

2452. ——— Untersuchungen über die entwicklung des os hypoischium (os cloacae aut.), os epipubis und ligamentum medianum pelvis bei den eidechsen. Morph. jahrb., xvii, 123-143, taf. viii. **91.1.**

2453. Müller, A. Beobachtungen zur vergleichenden anatomie der wirbelsäule. Müller's Arch., 260-316, taf. viii. **53.1.**

2454. Nesbitt, Robert. Human osteogeny explained in two lectures read in the anatomical theatre of the surgeons of London. London, xiii, 170 p. 6 pl. 8vo. **1736.1.**

2455. Parker, T. J. On the origin of the sternum. Trans. proc. New Zealand inst., xxiii, 119-123, pl. xix. **91.1.**

2456. Parker, W. K. Remarks on the skeleton of the Archaeopteryx and on the relations of the bird to the reptile. Geol. mag., ii, 55-57. **64.2.**

2457. ——— Monograph on the structure and development of the shoulder-girdle and sternum in the Vertebrata. Ray soc. London, xi, 237 p. 30 pls. fol. **68.1.**

2458. ——— On the skeleton of the marsipobranch fishes; pt. i. The myxinoids (Myxine and Bdello stoma). ii. Petromyzon. Phil. trans. roy. soc. Lond., clxxiv, 373-457, pls. viii-xxvi. Separate: London, 86 p., 19 pls. Abstract: Nature, xxvii, 330-331. **83.1.**

2459. Planteau, H. Développement de la colonne vertébrale. Paris, 113 p., 1 pl. 4to. **83.1.**
2460. Rathke, H. Zur entwickelungsgeschichte der thiere. Müller's Arch., 361-372. **38.2.**
2461. ——— Ueber den bau und die entwickelung des brustbeins der saurier. Königsberg, 56 p. **53.1.**
2462. Robin, Charles. Mémoire sur le développement des vertèbres atlas et axis. Journ. anat. et phys. Paris, i, 274-299, 4 pls. **64.1.**
2463. Rosenberg, E. Ueber die entwickelung der wirbelsäule und das centrale carpi des menschen. Morph. jahrb., i, 83-197, taf. iii-v. **75 1.**
2464. Ruge, G. Ueber die entwicklung des sternums. Morph. jahrb., v, 192. **79.1.**
2465. ——— Untersuchungen über entwicklungsvorgänge am brustbeine und an der sternoclavicularverbindung des menschen. Morph. jahrb., vi, 362-414, taf. xvii-xix. **80.1.**
2466. Schulin, K. Ueber die entwickelung und weitere ausbildung der gelenke des menschlichen körpers. His's Arch., 240-274, taf. x-xi. **79.1.**
2467. Schwarck, W. Beiträge zur entwickelungsgeschichte der wirbelsäule bei den vögeln. Hasse's Anat. studien, i, 569-582, taf. xxvi. **72.1.**
2468. Schwegel, A. Die entwicklungsgeschichte der knochen des stammes und der extremitäten, mit rücksicht auf chirurgie, geburtskunde und gerichtliche medicin. Sitzb. Wien. akad., xxx, 337-388. **58.1.**
2469. Strasser, H. Zur entwicklung des knorpelskelettes bei tritonen. Zool. anz., i, 192-195. **78.1.**
2470. Sutton, J. B. On the nature of certain ligaments. Journ. anat. phys., xviii, 225-238, pl. xiii. **84.1.**
2471. Swirski, Georg. Untersuchungen über die entwickelung des schultergürtels und des skelets der brustflosse des hechts. Dorpat, 60 p., 2 pls. 8vo. (Inaug. diss.) **80.1.**
2472. Tornier, Gustav. Die phylogenese des terminalen segmentes der säugethier-hintergliedmassen. Morph. jahrb., xvi, 401-483, taf. xvii-xviii. **90.1.**
2473. Wiedersheim, R. Ueber die entwicklung des schulter- und beckengürtels. Anat. anz., iv, 428-441. **89.1.**

SKULL.

2474. Bertrand, Camille. Anatomie philosophique; conformation osseuse de la tête chez l'homme et les vertébrés. Paris, xxxii, 256 p., 10 pls. 8vo. **62.1.**
2475. Bianchi, S. Sullo sviluppo della squama occipitale e sul modo di originarsi delle varie forme delle ossa interparietali e preinterparietali nel cranio umano. Monitore zool. ital., ii, 69-77, 91-97. **91.2.**
2476. Bidder, A. A. De cranii conformatione, ratione imprimis habita Jacobsonii de cranio primordiali ejusque ossificatione sententiae. Dorpat, 50 p., 1 pl. **47.1.**
2477. Blake, J. E. Premature ossification of the foetal cranium as a cause of dystocia and of impairment of intellect in children. Am. journ. obstr., xii, 225-235. **79.1.**
2478. Champeil, J. Recherches histologiques sur la voûte du crâne membraneux primordial. Journ. anat. et phys., xxv, 640-669, pl. xx. **89.1.**
2479. Decker, F. Ueber dem primordialschädel einiger säugethiere. Zeitschr. wiss. zool., xxxviii, 190-233, taf. ix. **83.1.**
2480. Dollo, J. On the malleus of the Lacertilia and the malar and quadrate bones of Mammalia. Q. J. M. S., xxiii, 579-596, pl. xli. **83.1.**
2481. Froriep, A. Zur entwicklungsgeschichte der wirbelsäule insbesondere des atlas und epistropheus und der occipitalregion. Arch. f. anat. u. phys., anat. abth., 177-234, taf. vii-ix. **83.1.** (Compare no. 2422.)
2482. ——— Bemerkungen zur frage nach der wirbeltheorie des kopfskelettes. Anat. anz., ii, 815-835. **87.2.**
2483. Gaupp, E. Zur kenntniss des primordialcraniums der amphibien und reptilien. Verh. anat. ges., v, 114-120. **91.1.**
2484. Gegenbaur, C. Das kopfskelet der selachier; ein beitrag zur erkenntniss der genese des kopfskelets der wirbelthiere. Leipzig, vi, 316 p., taf. i-xxii, 4to. **72.1.**
2485. ——— Ueber das kopfskelet von Alepocephalus rostratus Risso. Morph. jahrb., iv, suppl., 1-42, taf. i-ii. **78.1.**
2486. Hanover, A. Primordialbrusken og dens forbening i det menneskelige kranium for fodselen. Dansk. vidensk. selsk. skrift. naturvid. og math. afd., 5, R. xi, 349-528, taf. 2. **80.1.**
2487. Hay, O. P. The skeletal anatomy of Amphiuma during its earlier stages. Journ. morph., iv, 11-34, pl. ii. **90.1.**
2488. Hertwig, O. Ueber das zahnsystem der amphibien und seine bedeutung für die genese des skelets der mundhöhle; eine vergleichend-anatomische entwicklungsgeschichtliche untersuchung. Arch. f. mikr. anat., xi, suppl., 1-208, taf. i-v. **74.2.**
2489. Hubrecht, A. A. W. Notiz über einige untersuchungen am kopfskelet der holocephalen. Morph. jahrb., iii, 280-282. **77.1.**
2490. Humphry. On the growth of the jaws. Journ. anat. phys., xii, 288-293. **78.1.**
2491. Huxley, T. H. On the theory of the vertebrate skull. Proc. roy. soc. Lond., ix, 381-433. **58.1.**
2492. ——— Lectures on the elements of comparative anatomy, on the classification of animals and on the vertebrate skull. London, xi, 303 p. **64.1.**
2493. Jhering, H. v. Die entwicklungsgeschichte des menschlichen stirnbeines. Arch. f. anat., phys. u. wiss. med., 649-658, taf. xcvii-c. **72.1.**

2494. Kölliker, A. Die theorie des primordialschädels. Zeitschr. wiss. zool., ii, 281-294. **50.2.**

2495. Kölliker, Theodor. Ueber das os intermaxillare des menschen und die anatomie der hasenscharte und des wolfsrachens. Nova acta Leop.-Carol. akad., xliii, 325-395, taf. xxii-xxviii. **82.1.**

2496. Kollmann, J. Deux espèces des variations corrélatives dans le crâne facial de l'homme. Assoc. franç. avanc. sc. Rouen. **83.1.**

2497. Martini, Vit. Sullo sviluppo delle ossa piatte secondari e del cranio da connettivo e sulla loro rigenerazione dopo la trapanazione. R. univ. Siena, 36 p., 2 pls. 8vo. **86.1.**

2498. Masquelin, H. Recherches sur le développement du maxillaire inférieur de l'homme. Bull. acad. Belg., sér. 2, xlv, 371-376. **78.1.**

2499. Noorden, Werner von. Beitrag zur anatomie der knorpeligen schädelbasis menschlicher embryonen. His's Arch., 241-257, taf. xvi. **87.1.**

2500. Parker, W. K. On the structure and development of the skull of the ostrich tribe. Phil. trans. roy. soc. Lond., clvi, 113-184. Abstract: Proc. roy. soc., xiv, 112-114. **66.2.**

2501. ——— On the structure and development of the skull of the common fowl (Gallus domesticus). Phil. trans. roy. soc. Lond., clix, 755-807, pls. lxxxi-lxxxvii. Abstract: Proc. roy. soc., xvii, 277-280. **69.3.**

2502. ——— On the structure of the eel's skull. Nature, iv, 146-148. **71.1.**

2503. ——— On the form and use of the facial arches. Monthly micr. journ., vi, 211-213. **71.2.**

2504. ——— On the mode of working out the morphology of the skull. Monthly micr. journ., v, 201-204. **71.3.**

2505. ——— On the structure and development of the skull of the common frog (Rana temporaria Linn.). Phil. trans. roy. soc. Lond., clxi, 137-211, pls. iii-x. Abstract: Proc. roy. soc., xix, 246-248. **71.4.**

2506. ——— On the structure and development of the crow's skull. Monthly micr. journ., viii, 217-226. 253, pls. xxxiv-xxxix. **72.1.**

2507. ——— On the structure and development of the skull of the salmon (Salmo salar Linn.). Phil. trans. roy. soc. Lond., clxiii, 95-145, pls. i-viii. Abstract: Proc. roy. soc., xx, 360-362. **73.1.**

2508. ——— On the development of the skull in the genus Turdus: the thrushes. Monthly micr. journ., ix, 102-107, pls. viii-x. **73.2.**

2509. ——— On the development of the skull in the tit (Parus) and sparrow hawk (Nisus vulgaris), parts i, ii. Monthly micr. journ., ix, 6-11, pl. ii; 45-50, pls. v-vi. **73.4.**

2510. ——— On the structure and development of the skull in the pig (Sus scrofa). Phil. trans. roy. soc. Lond., clxiv, 287-336, pls. xx-xxxvii. Abstract: Proc. roy. soc., xxi, 402-407. **74.1.**

2511. ——— On the skull of the aegithognathous birds, pt. i. Trans. zool. soc. Lond., ix, 289–352. pls. liv-lxii. **75.1.**

2512. ——— On the structure and development of the skull in the Batrachia, pt. ii. Phil. trans. roy. soc. Lond., clxvi, 601-669. **76.1.**

2513. ——— On the structure and development of the skull in urodelous Amphibia. Phil. trans. roy. soc. Lond., clxvii, 529-597, pls. xxi-xxix. Abstract: Journ. Linn. soc., zool., xiv, 717-719. **77.1.**

2514. ——— Structure and development of the skull in the common snake (Tropidonotus natrix). Phil. trans. roy. soc. Lond., clxix, 385-417, pls. xxvii-xxxiii. **78.1.**

2515. ——— On the structure and development of the skull in the Lacertilia; part i. On the skull of the common lizards, Lacerta agilis, L. viridis, and Zootoca vivipara. Phil. trans. roy. soc. Lond., clxx, 595-640, pls. xxxvii-xlv. Abstract: Proc. roy. soc., xxviii, 214-218. **79.1.**

2516. ——— On the structure and development of the skull in sharks and skates. Trans. zool. soc. Lond., x, 189-234, pls. xliv-xlv. **79.2.**

2517. ——— On the skull of the aegithognathous birds, pt. ii. Trans. zool. soc. Lond., x, 251-314, pls. xlvi-liv. **79.4.**

2518. ——— On the structure and development of the skull in the Batrachia, pt. iii. Phil. trans. roy. soc. Lond., clxxii, 1-266, pls. i-xliv. **81.2.**

2519. ——— On the structure of the skull in the chameleons. Trans. zool. soc. Lond., xi, 77-105, pls. xv-xix. **81.3.**

2520. ——— On the structure and development of the skull in sturgeons (Acipenser ruthenus and A. sturio). Phil. trans. roy. soc. Lond., clxxiii, 139-186, pls. xii-xviii. **82.1.**

2521. ——— On the structure and development of the skull of the urodeles. Trans. zool. soc. Lond., xi, 171-214, pls. xxxvi-xli. Abstract: Proc. zool. soc., iv (1880), 544-545. **82.2.**

2522. ——— On the morphology of the skull in the Amphibia Urodela. Trans. Linn. soc. Lond., sev. 2, zool., ii, 165-212, pls. xiv-xxi. **82.3.**

2523. ——— On the development of the skull in Lepidosteus osseus. Phil. trans. roy. soc. Lond., clxxiii, 443-492, pls. xxx-xxxviii. Abstracts: Proc. roy. soc., xxxiii, 107-112; Nature, xxv, 330-331. **82.4.**

2524. ——— On the structure and development of the skull in the Crocodilia. Trans. zool. soc. Lond., xi, 263-310, pl. lxii-lxxi. Abstracts: Proc. zool. soc., 97-98; Nature, xxvi, 252-254. **83.2.**

2525. ——— On the structure and development of the skull in the Mammalia; pt. ii. Edentata. Phil. trans. roy. soc. Lond., clxxvi, 1-119, pls. i-xv. Abstract: Proc. roy. soc., xxxvii, 78-82. **86.1.**

2526. ——— On the structure and development of the skull in the Mammalia; pt. iii. Insectivora. Phil. trans. roy. soc. Lond., clxxvi, 121-275, pls. xvi-xxxix. Abstract: Proc. roy. soc., xxxviii. 129-138. **86.2.**

2527. Parker, W. K., *and* Bettany, G. T. The morphology of the skull. London, vii, 368 p., 85 figs. 12mo. **77.1.** Deutsche ausgabe von B. Vetter, Stuttgart, 1879.
2528. Rathke, Heinrich. Bemerkungen über die entwickelung des schädels der wirbelthiere. Ber. naturw. seminar univ. Königsberg. **39.2.**
2529. Reichert, K. B. Zur kontroverse über den primordialschädel. Müller's Arch., 443-516. **49.1.**
2530. Rosenberg, E. Untersuchungen über die occipitalregion des cranium und den proximalen theil der wirbelsäule einiger selachier. Dorpat, 26 p., 2 pls. 4to. **84.1.**
2531. Schwink, T. Ueber den zwischenkiefer und seine nachbarorgane bei säugethieren. München, vi, 84 p., 5 pls. 4to. **88.2.**
2532. Semmer, A. Untersuchungen über entwicklung des Meckel'schen knorpels und seiner nachbargebilde. Dorpat, 76 p., 2 pls. 8vo. (Diss.) **72.1.**
2533. Sewertzow, A. N. Ueber einige eigentümlichkeiten in der entwickelung und im bau des schädels von Pelobates fuscus. Bull. soc. nat. Moscou, 143-160. **91.1.**
2534. Spöndli, H. Ueber den primordialschädel der säugethiere und des menschen. Zürich, 38 p., 1 pl. 8vo. **46.1.**
2535. Stöhr, Ph. Zur entwicklungsgeschichte des urodelenschädels. Z. Z., xxxiii, 477-526, taf. xxix-xxx. **80.1.**
2535a. ——— Ueber wirbeltheorie des schädels. Sitzb. phys.-med. ges. Würzburg, 41-44. **81.1.**
2536. ——— Zur entwicklungsgeschichte des kopfskeletes der teleostier. Festschr. z. 3. säcularfeier med. fac. Würzb., Leipzig, ii, 71-95, 2 pls. **82.1.**
2537. ——— Zur entwicklungsgeschichte des anurenschädels. Zeitschr. wiss. zool., xxxvi, 68-103, taf. ii-iii. **82.2.**
2538. Virchow, R. Untersuchungen über die entwickelung des schädelgrundes im gesunden und krankhaften zustande, etc. Berlin, 128 p., 6 pls. fol. **57.1.**
2539. Vrolik, A. J. Studien über die verknöcherung und die knochen des schädels der teleostier. Niederl. arch. zool., i, 219-318, taf. xviii-xxii. **73.1.**

SPERMATOGENESIS.

2540. Beauregard, H. Note sur la spermatogénèse chez la cantharide. C. R. soc. biol. Paris, sér. 8, iv, 331-333. **87.1.**
2541. Benda, C. Zur spermatogenese und hodenstruktur der wirbelthiere. Anat. anz., ii, 368-370, 370-371. **87.2.**
2542. Beneden, E. van, *and* Julin, C. La spermatogénèse chez l'Ascaris megalocephala. Bull. acad. Belg., sér. 3, vii, 312-342. **84.2.**
2543. Bergonzini, C. Contributo allo studio della spermatogenesi nei vertebrati. Rassegna sc. med. Modena, iii, 337-344, 366-374, 419-425, 469-474, 1 pl. **88.1.**
2544. Biondi, D. Die entwickelung der spermatozoiden. Arch. f. mikr. anat., xxv, 594-620, taf. xxvi-xxvii. **85.1.**
2545. ——— Ueber die entwickelung der samenfäden beim menschen. Jahresber. schles. ges. f. vaterländ. cult. Breslau, lxv, 35-38. **88.1.**
2546. Blomfield, J. E. On the development of spermatozoa; pt. i. Lumbricus. Q. J. M. S., xx, 79-89, pl. vi. **80.1.**
2547. ——— On the development of the spermatozoa; pt. ii. Helix and Rana. Q. J. M. S., xxi, 415-431, pl. xxiv-xxv. **81.1.**
2548. ——— Review of recent researches on spermatogenesis. Q. J. M. S., xxiii, 320-335. **83.1.**
2549. Bronn, H. H. On spermatogenesis in the rat. Q. J. M. S., xxv, 343-369, pl. xxii-xxiii. **85.1.**
2550. Brunn, A. von. Beiträge zur entwickelungsgeschichte der samenkörper. Arch. f. mikr. anat., xii, 528-535, taf. xxii. **76.1.**
2551. Campbell, Douglas H. Zur entwicklungsgeschichte der spermatozoiden. Ber. deutsch. bot. ges., v, 120-127, taf. vi. **87.1.**
2552. Cuccati, G. Spermatogenesi nella Rana esculenta. Anat. anz., v, 344-346. **90.1.**
2553. Cunningham, J. T. Spermatogenesis in Myxine glutinosa. Q. J. M. S., xxxiii, 169-186, pl. iv. **91.3.**
2554. Ebner, V. v. Zur spermatogenese bei den säugethieren. Arch. f. mikr. anat., xxxi, 236-292, taf. xv-xvii. **88.1.**
2555. Ferrari, C. Sulla spermatogenesi nei mammiferi. Mem. accad. sc. ist. Bologna, ser. 4, x, 181-199, tav. i. **89.1.**
2556. Flemming, W. Neue beiträge zur kenntniss der zelle. Arch. f. mikr. anat., xxix, 389-463, taf. xxiii-xxvi. **87.1.**
2557. ——— Weitere beobachtungen über die entwicklung der spermatosomen bei Salamandra maculosa. Arch. f. mikr. anat., xxxi, 71-97, taf. vii. **87.2.**
2558. Fürst, C. M. Ueber die entwickelung der samenkörperchen bei beuteltieren. Arch. f. mikr. anat., xxx, 336-365, pls. xviii-xx. **87.1.**
2559. Geddes, P., *and* Thomson, J. A. History and theory of spermatogenesis. Proc. roy. soc. Edinb., xiii, 803-823, pl. xxix. **86.1.**
2560. Omitted.
2561. Gilson, G. Étude comparée de la spermatogénèse chez les arthropodes; troisième partie. Acariens, aperçu synthétique, conclusions. La cellule, iv, 351-446, pl. xvi. **87.1.**
2562. Grandis, V. La spermatogénèse durant l'inanition. Arch. ital. biol., xii, 215-223. **89.1.**
2563. Henking, H. Untersuchungen über die ersten entwicklungsvorgänge in den eiern der insekten; ii. Ueber spermatogenese und deren beziehung zur eientwicklung bei Pyrrhocoris apterus L. Zeitschr. wiss. zool., li, 685-736, taf. xxxv-xxxvii. **91.1.**

2564. Hermann, F. Beiträge zur histologie des hodens. Arch. f. mikr. anat., xxxiv, 58-106, taf. iii-iv. **89.1**.
2565. Hermann, G. Recherches sur la spermatogénèse chez les sélaciens. Robin's Journ. anat. phys., xviii, 373-432, pls. xxiv-xxvi. Preliminary notice: C. R. acad. sc. Paris, xciii, 358-360. **82.1**.
2566. Jensen, O. S. Recherches sur la spermatogénèse. Arch. de biol., iv, 1-94, pl. i-ii; 669-747, pl. xx, figs. 1-34. **83.1**.
2567. Kolosson, A. Beitrag zur lehre von der entwickelung der samenfäden bei säugetieren. Centralbl. f. med. wiss., xxvi, 561-565. **88.1**.
2568. Korotnef, de. Sur la spermatogénèse. C. R. acad. sc. Paris, cv, 953-955. **87 1**.
2569. Lee, Arthur Bolles. La spermatogénèse chez les némertiens, à propos d'une théorie de Sabatier. Recueil zool. suisse, iv, 409-430, pl. xix. **87.1**.
2570. ——— La spermatogénèse chez les chétognathes. La cellule, iv, 107-133, pls. i-ii. **87.2**.
2571. Merkel, F. Die stützzellen des menschlichen hodens. Müller's Arch., 1-13, taf. i. **71.1**.
2572. ——— Erstes entwickelungstadium der spermatozoiden. Untersuch. anat. inst. Rostock, 22-37, pl. i. **74.1**.
2573. Miescher. Die spermatozoen einiger wirbelthiere; ein beitrag zur histochemie. Verh. naturf. ges. Basel, vi, 138-208, taf. i. **78 1**.
2574. Neumann, E. Untersuchungen über die entwickelung der spermatozoiden. Arch. f. mikr. anat., xi, 292-324, taf. xvii. **75.1**.
2575. Niessing, G. Untersuchungen über die entwicklung und den feinsten bau der samenfäden einiger säugetiere. Verh. phys.-med. ges. Würzburg, n. f. xxii, 35-63, taf. iv-v. **88.1**.
2576. Platner, Gustav. Ueber die spermatogenese bei den pulmonaten. Arch. f. mikr. anat., xxv, 564-581, taf. xxiii. **85.1**.
2577. Prenant, A. Note sur la cytologie des éléments séminaux chez la scolopendre. C. R. soc. biol. Paris, sér. 8, iv, 537-539. **87.1**.
2578. ——— Recherches sur la signification des éléments du tube séminifère adulte des mammifères (sur la question de la cellule de soutien). (Fin.) Intern. monatsschr. f. anat. u. phys., iv, 397-409, pls. xiv-xv. **87.2**.
2579. Renson, Geo. De la spermatogénèse chez les mammifères. Arch. de biol., iii, 291-334, pl. xii-xiii. **82.1**.
2580. Sabatier, A. De la spermatogénèse chez les annélides. Trav. lab. zool. Montpellier, sér. 1, v. 5-20, pls. i-ii. **82.1**.
2581. ——— De la spermatogénèse chez les némertiens. Trav. lab. zool. Montpellier, sér. 1, v, 21-38, pls. iii-v. **82.2**.
2582. Sanfelice, F. Spermatogénèse des vertébrés. Arch. ital. biol., x, 69-122. **88.1**.
2583. Schweigger-Seidel. Ueber die samenkörper und ihre entwickelung. Arch. f. mikr. anat., i, 309-335, taf. xix. **65.1**.
2584. Sertoli, E. Sulla struttura dei canalicoli seminiferi dei testicoli, studiata in rapporto allo sviluppo dei nemaspermi. Arch. sc. med. Torino, ii, 107-146, 267-295, pls. ii. **77.1**.
2585. ——— Sur la caryokinèse dans la spermatogénèse. Arch. ital. biol., vii, 369-376. **86.2**.
2586. Swaen, A., *and* Masquelin, H. Étude sur la spermatogénèse. Arch. de biol., iv, 749-801, pl. xxii-xxvi. **83.1**.
2587. La Valette, St. George de. Ueber die genese der samenkörper. Arch. f. mikr. anat., xv, 261-314, taf. xv-xix. **78.1**.
2588. Verson, E. Zur spermatogenesis. Zool. anz., xii, 100-103. **89.1**.
2589. Waldeyer, W. Bau und entwicklung der samenfäden. Anat. anz., ii, 345-368. **87.2**.
2590. Wiedersperg, Gustav von. Beiträge zur entwickelungsgeschichte der samenkörper. Arch. f. mikr. anat., xxv, 113-136, taf. v-vii. **85.1**.

SPERMATOZOA

2591. Ballowitz, Emil. Zur lehre von der struktur der spermatozoen. Anat. anz., i, 363-376. **86.1**.
2592. ——— Untersuchungen über die struktur der spermatozoen, zugleich ein beitrag zur lehre vom feineren bau der kontraktilen elemente. th. i. Die spermatozoen der vögel. Arch. f. mikr. anat., xxxii, 401-474, taf. xiv-xviii. **88.1**.
2593. ——— Untersuchungen über die struktur der spermatozoen, zugleich ein beitrag zur lehre vom feineren bau der kontraktilen elemente; Die spermatozoen der insekten; i. Coleopteren. Zeitschr. wiss. zool., l, 317-407, taf. xii-xv. **90.1**.
2594. ——— Untersuchungen über die struktur der spermatozoen; th. iii. Fische, amphibien und reptilien. Arch. f. mikr. anat., xxxvi, 225-290, taf. xi-xii. **90.2**.
2595. ——— Das Retzius'sche endstück der säugetiere-spermatozoen. Intern. monatsschr. f. anat. u. phys., vii, 211-223, taf. xi. **90.3**.
2596. ——— Weitere beobachtungen über den feineren bau der säugetierspermatozoen. Zeitschr. wiss. zool., lii, 217-293, taf. xii-xv. **91.1**.
2597. ——— Die bedeutung der Valentin'schen querbänder am spermatozoenkopfe der säugethiere. Arch. f. anat. u. phys., anat. abth., 193-211, taf. xii. **91.2**.
2598. Bardeleben, K. Ueber den feineren bau der menschlichen spermatozoen. Verh. anat. ges., v, 157-164. **91.1**.
2599. Bellonci, G. Sui nuclei polimorfi delle cellule sessuali degli anfibi. Accad. Bologna, 14 p., tav. i-ii. **86.1**.
2600. Benda, Carl. Ueber die spermatogenese der säugethiere. Du Bois Reymond's Arch. phys., 186-187, 386-388. **86.1**.
2601. ——— Untersuchungen über den bau des funktionirenden samenkanälchens einiger säugethiere und folgerungen für die spermatogenese dieser wirbelthier-klasse. Arch. f. mikr. anat., xxx, 49-110, taf. v-vii. **87.1**.

2602. Brock, J. Ueber die entwicklung der geschlechtsorgane der pulmonaten. Nachr. ges. wiss. Göttingen, 499-504. **84.1**.

2603. ——— Ueber die doppelten spermatozoen einiger exotischer prosobranchier. Zool. jahrb., ii, 615-624, taf. xvi. **87.5**.

2604. Brunn, A. von. Beiträge zur kenntniss der samenkörper und ihrer entwickelung bei säugethieren und vögeln. Arch. f. mikr. anat., xxiii, 108-132, taf. viiA. **83.1**.

2605. Brunn, Max von. Untersuchungen über die doppelte form der samenkörper von Paludina vivipara. Arch. f. mikr. anat., xxiii, 413-499, taf. xxi-xxii. **84.1**.

2606. Campana, M. Note sur la vie et la survie des spermatozoides à l'intérieur de l'oeuf chez les mammifères. C R. acad. sc. Paris, lxxxiv, 91-92. **77.1**.

2607. Czermak. Ueber die spermatozoiden von Salamandra atra. Uebersichtl. arb. schles. ges. vaterländ. cult. Breslau, xviii, 39. **49.1**.

2608. Dujardin, F. Sur les zoospermes des mammifères et sur ceux du cochon d'Inde en particulier. Ann. sc. nat., sér. 2, viii. 291-297. **37.1**.

2609. Ebner, Victor von. Untersuchungen über den bau der samenkanälchen und die entwicklung der spermatozoiden bei den säugethieren und beim menschen. Rollett's Unters. inst. phys.-hist. Graz, Leipzig, 1870, 200-236, taf. i. **71.1**.

2610. ——— Nachtrag zur spermatogenese bei den säugetieren. Arch. f. mikr. anat., xxxi, 424-425. **88.2**.

2611. Omitted.

2612. Eimer, Th. Untersuchungen über den bau und die bewegung der samenfäden. Verh. phys.-med. ges. Würzburg, n. f. vi. 93-136, taf. v. **74.3**.

2613. Flemming, W. Beiträge zur kenntniss der zelle und ihrer lebenserscheinungen, th. ii. Arch. f. mikr. anat., xviii, 151-259, taf. vii-ix. **80.1**. Theil iii, *ibid.*, xx, 1-86, taf. i-iv. **82.2**.

2614. Gibbes, H. On the structure of the vertebrate spermatozoon. Q. J. M. S., xix, 487-491, pl. xxiv. **79.1**.

2615. Jensen, O. S. Ueber die struktur der samenkörper bei säugethieren, vögeln und amphibien. Anat. anz., i, 251-257. **86.1**.

2616. ——— Untersuchungen über die samenkörper der säugethieren, vögeln und amphibien. Arch. f. mikr. anat., xxx, 379-425, taf. xxii-xxiv. **87.1**.

2617. Koehler, R. Sur la double forme des spermatozoides chez les Murex brandaris et trunculus et le développement de ces spermatozoides. C. R. acad. sc. Paris, cvi, 299-301. **88.1**.

2618. ——— Recherches sur la double forme des spermatozoides chez le Murex brandaris et le M. trunculus. Recueil zool. suisse, v, 101-150, pls. vi-vii. **88.2**.

2619. Kölliker, A. Physiologische studien über die samenflüssigkeit. Z. Z., vii, 201-272, taf. xiii. **55.2**.

2620. Korotnef, de. Beitrag zur spermatologie. Arch. f. mikr. anat., xxxi, 334-341, taf. xix. **88.1**.

2621. Krause, W. Zum spiralsaum der samenfäden. Biol. centralbl., i, 25-26. **81.4**.

2622. ——— Der spiralsaum der samenfäden. Internat. monatsschr. f. anat. u. phys., ii, 170-172, taf. xiB. **85.1**.

2623. Lode, Alois. Untersuchungen über die zahlen und regenerationsverhältnisse der spermatozoiden bei hund und mensch. Arch. f. ges. phys., l, 278-292. **91.1**.

2624. Nelson, E. M. Some observations on the human spermatozoon. Journ. Quekett micr. club Lond., ser. 2, iii, 310-314, pl. i. **89.1**.

2625. Piersol, Geo. A. The structure of spermatozoa, especially those of Amphiuma tridactylum. Univ. med. mag. Philadelphia, i, 662-669. **89.1**.

2626. Ploetz, A. J. Die vorgänge in den frosch-hoden unter dem einfluss der jahreszeit; vergleich von Rana temporaria und esculenta. Arch. f. anat. u. phys., phys. abth., suppl., 1-32, taf. i-ii. **90.1**.

2627. Prenant, A. Note sur la structure des spermatozoides chez l'homme. C. R. soc. biol. Paris, sér. 9, v, 288-290. **88.2**.

2628. ——— Remarques à propos de la structure des spermatozoides et du récent travail de Ballowitz. Revue biol. nord France, Lille, i, 299-305. **89.2**.

2629. Retzius, G. Zur kenntniss der spermatozoen. Biol. untersuch., i, 77-88, taf. x. **81.1**.

2630. Romiti, G. Sulla struttura dei nemaspermi dell' uomo. Bull. soc. cult. sc. med. Siena, ii. Reprinted in Romiti's Notizie anat., no. ix, 23-25. Abstract: Biol. centralbl., v (1885), 505. **84.1**.

2631. Rossi, U. Sulla distruzione degli spermatozoi negli organi genitali interni femminili del Mus musculus. Internat. monatsschr. f. anat. u. phys., vii, 196-202. **90.1**.

2632. Stassano. Contribuzione alla fisiologia degli spermatozoidi. Zool. anz., vi, 393-395. **83.1**.

2633. La Valette, St. George de. Spermatologische beiträge; mittheilung 1. [Bombinator.] Arch. f. mikr. anat., xxv, 581-593, taf. xxiv-xxv. **85.1**.

2634. ——— Spermatologische beiträge; mittheilung 2. [Blatta germanica.] Arch. f. mikr. anat., xxvii, 1-12, taf. i-ii. **86.1**.

2635. ——— Spermatologische beiträge; mittheilung 3. [Forms of spermat. in Anoura.] Arch. f. mikr. anat., xxvii, 385-397, taf. xiv-xvi. **86.2**.

2636. Wagner, Rudolph, *and* Leuckart, Rudolph. Semen. Todd's Cyclop., iv, pt. 1, 472-508. **48.1**.

SPLEEN.

2637. Howell, W. H. Spleen: histology and physiology of. Ref. Handb. med. sc., viii, 493-499. **89.1.**
2638. Laguesse, E. Recherches sur le développement de la rate chez les poissons. Journ. de l'anat., xxvi, 345-406, 425-495, pls. x-xiii. **90.1.**
2639. ——— Le tissu splénique et son développement. Anat. anz., vi, 131-134. **91.1.**
2640. Maurer, F. Die erste anlage der milz und das erste auftreten von lymphatischen zellen bei amphibien. Morph. jahrb., xvi, 203-208. **90.1.**
2641. Peremeschko. Beitrag zur anatomie der milz. Sitzb. Wien. akad., lv, 539-542, taf. i. **67.1.**
2642. ——— Ueber die entwicklung der milz. Sitzb. Wien. akad., lvi, 31-38, taf. i-ii. **67.2.**
2643. Phisalix, C. Recherches sur l'anatomie et la physiologie de la rate chez les icthyopsidés. Arch. zool. expér., sér. 2, iii, 369-464, pl. xviii-xxii. **85.1.**

SPINAL CORD.

2644. Barnes, Wm. On the development of the posterior fissure of the spinal cord, and the reduction of the central canal in the pig. Proc. Am. acad., xix, 97-110, pls. i-iii. **84.1.**
2645. Bechterew, W. Ueber die hinteren nervenwurzeln, ihre endigung in der grauen substanz des rückenmarkes und ihre centrale fortsetzung im letzteren. Arch. f. anat. u. phys., anat. abth., 126-136, taf. x. **87.1.**
2646. Bidder, F., *and* Kupffer, C. Untersuchungen über die textur des rückenmarks und die entwickelung seiner formelemente. Leipzig, viii, 122 p., taf. i-v, 4to. **57.1.**
2647. Boll, Franz. Die histologie und histiogenese der nervösen centralorgane. Arch. psychiatrie u. nervenkr., iv, 1-138, taf. i-ii. **73.1.**
2648. Bufalini, G. Sulla struttura del midollo spinale nel feto. Sperimentale, Firenze, xl, 537-539, xliii, 229. **77.1.**
2649. Clarke, J. L. Further researches on the grey substance of the spinal cord. Phil. trans. roy. soc. Lond., cxlix, 437-467, pl. xix-xxv. **59.1.**
2650. ——— Researches on the development of the spinal cord in man, Mammalia, and birds. Phil. trans. roy. soc. Lond., 911-938, pls. xlv-xlviii. **62.1.**
2651. Eichhorst, H. Ueber die entwickelung des menschlichen rückenmarkes und seiner formelemente. Virchow's Arch., 425-475, taf. xiii-xiv. **75.1.**
2652. Flechsig, P. Die leitungsbahnen im gehirn und rückenmark des menschen auf grund entwicklungsgeschichtlicher untersuchungen. Leipzig, xvi, 382 p. pls. i-xx. **76.1.**
2653. Freud, Sigmund. Ueber spinalganglien und rückenmark des Petromyzon. Sitzb. Wien. akad., lxxviii, abth. 3, 81-167. **78.1.**
2654. Gaule, Justus. Zahl und vertheilung der markhaltigen fasern im froschrückenmark. Abh. math.-phys. cl. sächs. ges. wiss., xv, 739-780, taf. i-x. **89.1.**
2655. His, W. Ueber das auftreten der weissen substanz und der wurzelfasern am rückenmark menschlicher embryonen. His's Arch., 163-170, taf. v. **83.1.**
2656. ——— Zur geschichte des menschlichen rückenmarkes und der nervenwurzeln. Abh. math.-phys. cl. sächs. ges. wiss., xiii, 479-513, 1 taf. **86.2.**
2657. Kölliker, A. von. Zur feineren anatomie des centralen nervensystems; beitrag 2. Das rückenmark. Zeitschr. wiss. zool., li, 1-54, taf. i-vi. **90.2.**
2658. ——— Ueber den feineren bau des rückenmarks. Sitzb. phys.-med. ges. Würzburg, 49-56. **90.3.**
2659. ——— Ueber den feineren bau des rückenmarks menschlicher embryonen. Sitzb. phys.-med. ges. Würzburg, 126-127. **90.4.**
2660. Lenhossék, Michael von. Untersuchungen über die entwickelung der markscheiden und den faserverlauf im rückenmark der maus. Arch. f. mikr. anat., xxxiii, 71-125, taf. vi-vii. **89.1.**
2661. Löwe, Ludwig. Beiträge zur anatomie und zur entwickelungsgeschichte des nervensystems der säugethiere und des menschen; 1. Die morphogenesis des centralen nervensystems. Berlin, 126 p. 18 pls. fol. **80.1.**
2662. ——— Beiträge zur anatomie und zur entwicklungsgeschichte des nervensystems der säugethiere und des menschen; 2. Die histologie und histogenese des nervensystems, nebst einem anhang: Die schädelwirbeltheorie. Leipzig, 50 p., pls. xix-xxiii, fol. **83.1.**
2663. Robinson, A. The development of the posterior columns of the posterior fissure and of the central canal of the spinal cord. Stud. anat., anat. dep. Owens coll., i, 67-102, pl. ii-iii. **91.1.**
2664. Romiti, G. Studi di embriogenia; ii. Sullo sviluppo del canale centrale della midolla spinale. Rivista clin. Bologna, ser. 2, iii, 367-369. **73.3.**
2665. Thanhoffer, L. Beiträge zur structur des centralen nervensystemes. Math. naturw. berichte aus Ungarn, v, 83-88. **87.1.**
2666. Tourneux, F., *and* Hermann, G. Sur l'existence d'un vestige caudal de la moelle épinière chez l'embryon de poulet. C. R. soc. biol. Paris, sér. 8, iv, 190-191. **87.1.**

2667. Fourneux, F., *and* Hermann, G. Sur la persistance de vestiges médullaires coccygiens pendant toute la période foetale chez l'homme et sur le rôle de ces vestiges dans la production des tumeurs sacrococcygiennes congénitales. Journ. anat. et phys., xxiii, 498-529, pls. xxiv-xxv. **87.3**.

2668. Vignal, W. Développement des éléments de la moelle épinière des mammifères. Arch. phys. norm. path., sér. 3, iv, 177-237, 364-426, pls. viii-x, xii-xvi. **84.1**.

2669. Waldeyer, W. Ueber die entwicklung des centralkanals im rückenmark. Arch. f. path. anat., lxviii, 20-26. **76.1**.

STOMACH.

2670. Brand, E. Beiträge zur entwickelung der magen- und darmwand. Würzburg, 8vo. (Inaug. diss.) **77.1**.

2671. Laskovsky. Ueber die entwicklung der magenwand. Sitzb. Wien. akad., lviii, 137-143, taf. i-ii. **68.1**.

2672. Martin, Paul. Die entwickelung des wiederkäuermagens und darmes. Schweiz. arch. f. thierheilk. Zürich, xxxi, 173-214, 1 pl. **89.1**.

2673. ——— Die entwickelung des wiederkäuermagens und darmes. Festschr. feier fünfzigj. von Nagel, etc., Zürich, 59-80, 1 pl. fol. **91.3**.

2674. Pilliet, A. Sur l'évolution des cellules glandulaires de l'estomac chez l'homme et les vertébrés. Journ. anat. et phys., xxiii, 463-498, pl. xxiii. **87.1**.

2675. Salvioli, I. Quelques observations sur le mode de formation et d'accroissement des glandes de l'estomac. Arch. ital. biol., xiv, 71-80. (Translation of 2676.) **90.1**.

2676. ——— Alcune osservazioni intorno al modo di formazione e di accrescimento delle glandole gastriche. Atti accad. sc. Torino, xxv, 462-477, tav. iv. **90.2**.

2677. Sclavunos, G. L. Untersuchungen über das eleidin und den verhornungsprocess an der pars cardiaca des magens der säugethiere, mit berücksichtigung der muskelfasern des magens der maus, der ratte und des schafes. Verh. phys.-med. ges. Würzburg, xxiv, 161-178, taf. vii. **90.1**.

2678. Sewall, Henry. The development and regeneration of the gastric glandular epithelium during foetal life and after birth. Journ. phys., i, 321-334, pl. xii. **78.1**.

2679. Toldt, C. Die entwickelung und ausbildung der drüsen des magens. Sitzb. Wien. akad., lxxxii, abth. 3, 57-128, taf. i-iii. **80.1**.

SUPRARENALS.

2680. Balfour, F. M. Ueber die entwicklung und die morphologie der suprarenalkörper (nebennieren). Abstract. Biol. centralbl., i, 136-138. **81.3**.

2681. Braun, M. Bau und entwicklung der nebennieren bei reptilien. Arb. zool.-zoot. inst. Würzburg, v, 1-30, taf. i-ii. **82.1**.

2682. Brunn, A. v. Ein beitrag zur kenntniss des feineren baues und der entwicklungsgeschichte der nebennieren. Arch. f. mikr. anat., viii, 618-638, taf. xxvii-xxviii. **72.1**.

2683. Dostoiewsky, A. Ein beitrag zur mikroskopischen anatomie der nebennieren bei säugethieren. Arch. f. mikr. anat., xxvii, 272-296, taf. xiii. **86.1**.

2684. Gottschau, M. Structur und embryonale entwickelung der nebennieren bei säugethieren. Arch. f. anat. u. phys., anat. abth., 412-458, taf. xviii-xix. Abstract: Biol. centralbl., iii, 565-576. **83.1**.

2685. Janosik, J. Bemerkungen über die entwicklung der nebenniere. Arch. f. mikr. anat., xxii, 738-746, taf. xxviiA.

2686. Mitsukuri, K. On the development of the suprarenal in Mammalia. Q. J. M. S., xxii, 17-29, pl. iv. **82.1**.

2687. Rabl, Hans. Die entwicklung und structur der nebennieren bei den vögeln. Arch. f. mikr. anat., xxxviii, 492-523, taf. xxix-xxxi. **91.1**.

2688. Valenti, G. Sullo sviluppo delle capsule surrenali nel pollo ed in alcuni mammiferi. Atti soc. tosc. sc. nat. Pisa, x, 122-148, tav. x. **89.1**.

2689. Weldon, W. F. R. Note on the origin of the suprarenal bodies of vertebrates. Proc. roy. soc. Lond., xxxvii, 422-425. **84.2**.

2690. ——— On the suprarenal bodies of Vertebrata. Q. J. M. S., xxv, 137-150, pls. xi-xii. **85.1**.

SYMPATHETIC.

2691. Birdsall, W. R. The embryogeny of the sympathetic. Arch. med., i, 138-149. **79.1**.

2692. Onodi, A. D. Ueber die entwickelung des sympathischen nervensystems. Arch. f. mikr. anat., xxvi, 61-81, taf. iv. **86.1**.

2693. Paterson, A. M. Development of the sympathetic nervous system in mammals. Phil. trans. roy. soc. Lond., clxxxi, 159-186, pls. xxii-xxx. **91.1**.

2694. Schenk, S., *and* Birdsall, W. Ueber die lehre von der entwicklung der ganglien des sympathicus. Mitth. embryol. inst. univ. Wien, i, 213-228, taf. xviii-xx. **80.1**.

SYNOVIA.

2695. Hagen-Torn, O. Entwickelung und bau der synovialmembranen. Arch. f. mikr. anat., xxi, 591-663. Abstract: Jahresber. anat. für 1882, 63-65. **82.1**.

2696. Henke, W., *and* Reyher, C. Studien über die entwicklung der extremitäten des menschen, insbesondere der gelenkflächen. Sitzb. Wien. akad., lxx, abth. 3, 217-273, taf. i-iv. **74.1**.

2697. Moser, E. Beitrag zur kenntniss der entwickelung der knieschleimbeutel beim menschen. Schwalbe's Morph. arb. Jena, i, 267-288. **91.1**.

TAIL.

2698. Braun, M. Entwicklungsvorgänge am schwanzende bei einiger säugethieren, mit berücksichtigung der verhältnisse beim menschen. Arch. f. anat. u. phys., anat. abth., 207-241, taf. xi-xii. **82.2**.

2699. ——— Ueber den schwanz bei säugethierembryonen. Deutsch. zeitschr. thiermed. Leipzig, ix, 93-94. **83.4**.

2700. Fol, H. Sur la queue de l'embryon humain. C. R. acad. sc. Paris, c, 1469-1472. **85 1**.

2701. His, W. Ueber den schwanztheil des menschlichen embryo. Arch. f. anat. u. phys., anat. abth., 431-440, taf. xxv. **80.3**.

TEETH.

2702. Boas, J. E. V. Die zähne der scaroiden. Z. Z., xxxii, 189-215, taf. x. **79.1**.

2703. Boll, Franz. Untersuchungen über die zahnpulpa. Arch. f. mikr. anat., iv, 73-87, taf. v. **68.1**.

2704. Brunn, A. von. Ueber die ausdehnung des schmelzorganes und seine bedeutung für die zahnbildung. Arch. f. mikr. anat., xxix, 367-383, taf. xxi-xxii. Anat. anz., i (1886), 259. **87.1**.

2705. ——— Ueber membrana praeformativa und cuticula dentis. Anat. anz., iii, 506-508. **88.1**.

2706. ——— Beiträge zur kenntniss der zahnentwickelung. Arch. f. mikr. anat., xxxviii, 142-156, taf. viii. **91.1**.

2707. Canalis, P. Sullo sviluppo dei denti nei mammiferi. Anat. anz., i, 187-188. **86.1**.

2708. Cope, E. D. On the homologies and origin of the types of molar teeth of Mammalia educabilia. Philadelphia, 21 p. 4to **74.1**.

2709. ——— The mechanical origin of the sectional teeth of the Carnivora. Proc. Am. assoc. adv. sc., xxxvi, 254-257. **87 2**.

2710. Czermak, Johann. Beiträge zur mikroskopischen anatomie der menschlichen zähne. Inaug. diss. 2 pls. **50.1**.

2711. Ebner, V. von. Histologie der zähne, mit einschluss der histogenese. Handb. zahnheilk., 209-262. **90.1**.

2712. ——— Strittige fragen über den bau des zahnschmelzes. Sitzb. Wien. akad., xcix, abth. 3, 59-104, 2 taf. **90.2**.

2713. Fleischmann, A. Die grundform der backzähne bei säugethieren und die homologie der einzelnen höcker. Sitzb. prenss. akad. Berlin, 891-903, taf. vii. **91.2**.

2714. Flower, W. H. On the development and succession of the teeth in the Marsupialia. Phil. trans. roy. soc. Lond., clvii, 631-641, pls. xxix-xxx. **67.1**.

2715. Huxley, T. H. On the development of the teeth and on the nature and import of Nasmyth's persistent capsule. Q. J. M. S., i, 149-164. **53.1**.

2716. ——— On the enamel and dentine of teeth. Q. J. M. S., iii, 127-130. **55.1**.

2717. Klever, E. Zur kenntniss der morphogenese des equidengebisses. Morph. jahrb., xv, 308-330, taf. xi-xiii. **89.1**.

2718. Kölliker, A. Ueber die entwicklung der zahnsäcken der wiederkäuer. Z. Z., xii, 455-460. **63.1**.

2719. Kollmann, J. Entwickelung der milch- und ersatzzähne beim menschen. Zeitschr. wiss. zool., xx, 145-235, taf. xiv-xv. **69.1**

2720. ——— Zahnbein, schmelz und cement. Zeitschr. wiss. zool., xxiii, 354-401, taf. xix-xxi. **73.1**.

2721. Kükenthal, Willy. Das gebiss von Didelphys. Anat. anz., vi, 658-666. **91.1**.

2722. Lataste, F. Considérations sur les deux dentitions des mammifères. Journ. anat. et phys., xxv, 200-222. **89.1**.

2723. Legros, Ch., *and* Magitot, É. Morphologie du follicule dentaire des vertébrés. Robin's Journ., 248-293. **79.1**.

2724. Lepkowski, W. Beitrag zur histologie des dentins, mit angabe einer neuen methode. Anat. anz., vii, 274-282, taf. i. **92.1**.

2725. Löwe, Ludwig. Beiträge zur kenntniss des zahnes und seiner befestigungsweise im kiefer. Arch. f. mikr. anat., xix, 703-720, taf. xxxi. **81.1**.

2726. Magitot, É. Détermination de l'âge de l'embryon humain par l'examen de l'évolution du système dentaire. C. R. acad. sc. Paris, lxxviii, 1206-1210. **74.1**.

2727. Magitot, É., *and* Legros, Ch. Origine et formation du follicule dentaire chez les mammifères. C. R. acad. sc. Paris, lxxvii, 1000-1003. Journ. anat. et phys., 449-503, pl. xv-xx. **73.1**.

2728. ——— Greffes de follicules dentaires et de leurs organes constitutifs isolément. C. R. acad. sc. Paris, lxxviii, 357-360. **74.1**.

2729. Mahn, R. Bau und entwickelung der molaren bei Mus und Arvicola. Morph. jahrb., xvi, 652-685, taf. xxv. **90.1**.

2730. Malassez, L. Sur l'existence d'amas épithéliaux autour de la racine des dents chez l'homme adulte et à l'état normal (débris épithéliaux paradentaires). Arch. de phys., sér. 3, v, 129-148, pl. iii-iv. **85.1**.

2731. Osborn, H. F. Evolution of mammalian molars to and from the tritubercular type. Am. nat., xxii, 1067-1079, pl. xxv. **88.2**.

2732. Owen, R. On the development and homologies of the molar teeth of the wart-hogs (Pharcochoerus), with illustrations of a system of notation for the teeth in the class Mammalia. Phil. trans. roy. soc. Lond., 481-498, pls. xxxiii-xxxiv. **50.1**.

2733. ——— Odontography; or, A treatise of the comparative anatomy of the teeth; their physiological relations, mode of development, and microscopic structure in the vertebrate animals. London, lxxiv, 655 p; atlas, 37 p., 150 pls. **40-45.4**.

2734. Pohlmann, J. The human teeth viewed in the light of evolution. Med. press west. N. Y., 245-250. **87.1**.

2735. Pouchet, G., *and* Chabry. Sur l'évolution des dents des balaenides. C. R. acad. sc. Paris, xciv, 540-542. **82.1**.

2736. Reichert, C. B. Beiträge zur entwicklungsgeschichte der zahnanlage. Müller's Arch., 539-578, taf. xiii-xivA. **69.1**.

2737. Röse, Carl. Ueber das menschliche gebiss. Verh. anat. ges., v, 165-168. **91.1**.

2738. ——— Ueber die entwicklung der zähne des menschen. Arch. f. mikr. anat., xxxviii, 447-491, taf. xxvii-xxviii. **91.2**.

2739. ——— Ueber die entwickelung des menschlichen gebisses. Verh. deutsch. odont. ges. Berlin, iii, 79-96. **91.3**.

2740. Roetter, F. Ueber entwickelung und wachstum der schneidezähne bei Mus musculus. Morph. jahrb., xv, 457-477, taf. xvii. **89.1**.

2741. Sihler, Chr. Notes on the formation of dentine and of osseous tissue. Stud. biol. lab. Johns Hopkins univ., ii, 45-57, pl. v. **83.1**.

2742. Spee, Graf. Ueber die ersten vorgänge der ablagerung des zahnschmelzes. Anat. anz., ii, 89-92. **87.1**.

2743. Thomas, O. On the homologies and succession of the teeth in the Dasyuridae, with an attempt to trace the history of the evolution of mammalian teeth in general. Phil. trans. roy. soc. Lond., clxxviii, 443-462, pls. xxvii-xxviii. **88.1**.

2744. Tomes, C. S. On the existence of an enamel organ in an armadillo. Q. J. M. S., xiv, 44-48. **74.1**.

2745. ——— On the development of the teeth of the newt, frog, slow worm and green lizard. Phil. trans. roy. soc. Lond., clxv, 285-296, pls. xlvi-xlvii. **75.1**.

2746. ——— On the structure and development of the teeth of Ophidia. Phil. trans. roy. soc. Lond., clxv, 297-302, pl. xlvii. **75.2**.

2747. ——— On the development of teeth in fishes (Elasmobranchii and Teleostei). Phil. trans. roy. soc. Lond., clxvi, 257-268, pl. xxxi. **76.1**.

2748. ——— On the development of teeth. Q. J. M. S., xvi, 40-50, pls. iv-v. **76.2**.

2749. ——— On the development and succession of the poison fangs of snakes. Phil. trans. roy. soc. Lond., clxvi, 377-386, pl. xxxviii. **76.3**.

2750. ——— On the structure and development of vascular dentine. Phil. trans. roy. soc. Lond., clxix, 25-47, pl. **79.1**.

2751. Waldeyer, W. Structure and development of the teeth. (Translated by Power.) Stricker's Histology, 321-341. **72.1**.

2752. Walkhoff. Die normale entwickelung und die physiologie des zahnbeines in den verschiedenen altersperioden des menschen. Deutsch. monatschr. f. zahnheilk. Leipzig, v, 246-259. **87.1**.

2753. Weil. Entwicklung des embryo, mit besonderer berücksichtigung der entwicklung der zähne. Deutsch. monatschr. f. zahnheilk. Leipzig, v, 81-90. **87.1**.

2754. Williams, J. L. Embryology: with special reference to the development of the teeth and contiguous parts. Dental cosmos. **84.1**.

2755. Zuckerland, E. Ueber das epitheliale rudiment eines vierten mahlzahnes beim menschen. Wien. med. blätter, xiv, 591-592. **91.1**.

TELEOSTS.

2756. Agassiz, A., *and* Whitman, C. O. On the development of some pelagic fish eggs. Preliminary notice. Proc. Am. acad. arts sc., xx, 23-75, pl. i. **84.1**.

2757. ——— The development of osseous fishes; i. The pelagic stages of young fishes. Mem. mus. comp. zool., xiv, 56 p., pls. i-xix. **85.1**.

2758. ——— The development of osseous fishes; ii. The pre-embryonic stages of development; part i. The history of the egg from fertilization to cleavage. Mem. mus. comp. zool., xiv, 40 p., pls. xx-xxxi. **89.1**.

2759. Aubert. Beiträge zur entwicklungsgeschichte der fische; i. Die rotation des dotters während der ersten entwickelung des hechteies. Z. Z., v, 94-102, taf. vi. **54.1**.

2760. Baer, C. E. von. Untersuchungen über die entwickelungsgeschichte der fische, nebst einem anhange über die schwimmblase. Leipzig, 52 p. 1 taf. **35.1**.

2761. Bambeke, Ch. van. Premiers effets de la fécondation sur les oeufs de poissons; sur l'origine et la signification du feuillet muqueux ou glandulaire chez les poissons osseux. C. R. acad. sc. Paris, lxxiv, 1056-1060. **72.1**.

2762. Bambeke, Ch. van. Recherches sur l'embryologie des poissons osseux; i. Modification de l'oeuf non fécondé après la ponte; ii. Premières phases du développement; bibliographie. Mém. cour. acad. Belg., xl, 66 p., pls. i-iii. **76.1**.

2763. ——— Remarques sur la reproduction de la blennie vivipare (Zoarces viviparus Cuv.). Bull. acad. Belg., sér. 3, xv, 92-117. **88.1**.

2764. Beneden, E. van. A contribution to the history of the embryonic development of teleosteans. Q. J. M. S., xviii, 41-57, pl. iv. **78.1**.

2765. Brook, George. The development of Motella mustela. Journ. Linn. soc. Lond., zool., xviii, 298-307, pls. viii-x. **84.1**.

2766. ——— The formation of the germinal layers in Teleostei. Trans. roy. soc. Edinb., xxxiii, 199-239, pls. xiii-xv. **86.2**.

2767. Clapp, Cornelia M. Some points in the development of the toad fish (Batrachus tau). Journ. morph., v, 494-501. **91.1**.

2768. Cunningham, J. T. Studies of the reproduction and development of teleostean fishes occurring in the neighbourhood of Plymouth. Journ. mar. biol. assoc. United Kingdom, Plymouth, n. s., i, 10-34. **89.1**.

2769. ——— On some disputed points in teleostean embryology. Ann. mag. nat. hist., ser. 6, vii, 203-221. **91.1**.

2770. Eigenmann, C. H. On the precocious segregation of the sex cells in Micrometrus aggregatus Gibbons. Journ. morph., v, 481-493, pl. xxxi. **91.1**.

2771. Goette, A. Beiträge zur entwickelungsgeschichte der wirbelthiere. Arch. f. mikr. anat., ix, 679-708, taf. xxvii. **73.1**.

2772. Goronowitsch, N. Studien über die entwicklung des medullarstranges bei knochenfischen, nebst beobachtungen über die erste anlage der keimblätter und der chorda bei salmoniden. Morph. jahrb., x, 376-445, taf. xviii-xxi. **85.1**.

2773. Hemeguy, L. F. Sur le mode d'accroissement de l'embryon des poissons osseux. C. R. acad. sc. Paris, civ, 85-87. **87.1**.

2774. ——— Recherches sur le développement des poissons osseux; embryogénie de la truite. Journ. anat. et phys., xxiv, 413-502, 525-617, pls. xviii-xxi. **88.1**.

2775. His, Wilhelm. Untersuchungen über das ei und die eientwickelung bei knochenfischen. Leipzig, iv, 54 p., taf. i-iv, 4to. **73.1**.

2776. ——— Untersuchungen über die entwicklung der knochenfische besonders über diejenige der salmen. Zeitschr. f. anat. u. entwick., i, 1-39, taf. i-ii. **76.1**.

2777. ——— Untersuchungen über die bildung des knochenfischembryo (salmen), ii. Arch. f. anat. u. phys., anat. abth., 180-221, taf. ix. **78.1**.

2778. Omitted.

2779. Hoffmann, C. K. Zur ontogenie der knochenfische. Verh. akad. v. wetensch. Amsterdam, xxi, 1-168, taf. i-vii. **81.2**.

2780. ——— Sur l'origine de feuillet blastodermique moyen chez les poissons cartilagineux. Arch. Néerland., xviii, 241-258, pl. iii-iv. **83.2**.

2781. ——— Zur ontogenie der knochenfische. Verh. akad. v. wetensch. Amsterdam, xxiii, 1-60, taf. i-iv. **83.4**.

2782. ——— Zur ontogenie der knochenfische. Arch. f. mikr. anat., xxiii, 45-108, taf. iv-vi. **84.4**.

2783. ——— Ueber den ursprung und die bedeutung der sogenannten freien kerne in dem nahrungsdotter bei den knochenfischen. Zeitschr. wiss. zool., xlvi, 517-548, taf. xxxv. **88.1**.

2784. Kingsley, J. S., *and* Conn, H. W. Some observations on the embryology of the teleosts. Mem. Bost. soc. nat. hist., iii, 183-212, pls. xiv-xvi. **83.1**.

2785. Klein, E. Observations upon the early development of the common trout. Q. J. M. S., xvi, 113-131, pl. vi. **76.1**.

2786. Kowalewski, Miecz. von. Ueber die ersten entwickelungsprocesse der knochenfische. Z. Z., xliii, 434-480, taf. xvii. **86.1**.

2787. ——— Die gastrulation und die sogenannte allantois bei den teleostiern. Sitzb. phys.-med. soc. Erlangen, 31-36. **86.2**.

2788. Kupffer, C. Beobachtungen über die entwicklung der knochenfische. Arch. f. mikr. anat., iv, 209-272, taf. xvi-xviii. **68.1**.

2789. Lereboullet, A. Résumé d'un travail d'embryologie comparée sur le développement du brochet, de la perche et de l'écrevisse. Ann. sc. nat., sér. 4, i, 237-289; ii, 39-80. **54.1**.

2790. ——— Recherches sur les monstruosités du brochet observées dans l'oeuf et sur leur mode de production. Ann. sc. nat., sér. 4, xvi, 359-368; xx (1863), 177-270, pls. ii-iii. C. R. acad. sc. Paris, liii, 957-959. **61.1**.

2791. ——— Recherches d'embryologie comparée sur le développement de la truite, du lézard et du limnée. Ann. sc. nat., sér. 4, xix, 5-100. **63.1**.

2792. List, J. Zur herkunft des periblastes bei den knochenfischen (labriden). Biol. centralbl., vii, 81-88. **88.1**.

2793. McIntosh, W. C., *and* Prince, E. E. On the development and life histories of the teleostean, food, and other fishes. Trans. roy. soc. Edinb., xxxv, 665-946, pls. i-xxviii. **90.1**.

2794. McMurrich, J. Playfair. On the osteology and development of Syngnathus peckianus (Storer). Q. J. M. S., xxiii, 623-650, pls. xlii-xliii. **83.1**.

2795. Marion, A. F. Oeufs flottants et alevins observés dans le golfe de Marseille durant l'année. Ann. mus. hist. nat. Marseille, iv, 112-121. **91.1.**

2796. Oellacher, J. Beiträge zur entwicklungsgeschichte der knochenfische nach beobachtungen am bachforelleneie. Z. Z., xxii, 373-421, taf. xxxii-xxxiii. **72.3.**

2797. ——— Beiträge zur entwicklungsgeschichte der knochenfische nach beobachtungen am bachforelleneie, cap. iii-v. Z. Z., xxiii, 1-115, taf. i-iv. **73.1.**

2798. ——— Ueber eine im befruchteten forellenkeime vor den einzelnen furchungsacten zu beobachtende radiäre structur des protoplasmas. Ber. natur.-med. ver. Innsbruck, v, 13-19. **75.1.**

2799. Owsjannikow, Ph. Studien über das ei, hauptsächlich bei knochenfischen. Mém. acad. St. Pét., sér. 7, xxxiii, 54 p., taf. i-iii. **85.1.**

2800. Pouchet, G. Du développement du squelette des poissons osseux. Journ. anat. et phys., xi, 288-308. **75.1.**

2801. Prince, E. E. On the nest and development of Gastrosteus spinachia at the St. Andrews Marine Laboratory. Ann. mag. nat. hist., ser. 5, xvi, 487-496, pl. xiv. **85.2.**

2802. ——— Early stages in the development of the food fishes. Ann. mag. nat. hist., ser. 5, xvii, 443-461. **86.1.**

2803. Ransom, W. Observations on the ovum of osseous fishes. Phil. trans. roy. soc. Lond., clvii, 431-501, pls. xv-xviii. **67.1.**

2804. Reinhard, W. Entwicklung der keimblätter der chorda und des mitteldarmes bei den cyprinoiden. Zool. anz., xi, 648-655. **88.1.**

2805. Rieneck. Ueber die schichtung des forellenkeims. Arch. f. mikr. anat., v, 356-366, taf. xxi, fig. 1-2. **69.1.**

2806. Rusconi. Sur les changemens que les oeufs des poissons éprouvent avant qu'ils aient pris la forme d'embryon. Ann. sc. nat., zool., sér. 2, v, 300-312. **36 1.**

2807. Ryder, J. A. Development of the silver gar (Belone longirostris) with observations on the genesis of the blood in embryo fishes and a comparison of fish ova with those of other vertebrates. Bull. U. S. fish comm., i, 283-335, pl. xix-xxi. **81.2.**

2808. ——— Observations on the absorption of the yelk, the food feeding and development of embryo fishes, comprising some investigations conducted at the central hatchery, Armory Building, Washington, D. C., 1882. Bull. U. S. fish comm., ii, 179-205. **82.1.**

2809. ——— A contribution to the embryography of osseous fishes, with special reference to the development of the cod (Gadus morrhua). Ann. rep. U. S. fish comm., pt. 10 (1882), 455-605, 12 pls. **84.1.**

2810. ——— Development of viviparous minnows (Gambrusia patruelis). Science, iii, 769. **84.2.**

2811. ——— On the morphology and evolution of the tail of osseous fishes. Nature, xxx, 601. **84.3.**

2812. ——— On the development of osseous fishes including marine and fresh-water forms. Ann. rep. U. S. fish comm., pt. 13 (1885), 489-604, 30 pls. **85.1.**

2813. ——— On the development of viviparous osseous fishes and of the Atlantic salmon. Proc. U. S. nat. mus., viii, 128-162, pl. vi-xii. **85.3.**

2814. ——— On the position of the yolk blastopore as determined by the size of the vitellus. Am. nat., xix, 411-415. **85.6.**

2815. ——— An outline of a theory of the development of the unpaired fins of fishes. Am. nat., xix, 90-97. **85.7.**

2816. ——— On the value of the fin-rays and their characteristics of development in the classification of the fishes, together with remarks on the theory of degeneration. Proc. U. S. nat. mus., ix, 71-82. **86.1.**

2817. ——— On the origin of heterocercy and the evolution of the fin-rays of fishes. Ann. rep. U. S. fish comm., pt. 12 (1884), 981-1085, pls. i-xi. **86.2.**

2818. Vogt, Carl. Embryologie des salmones. Hist. nat. d. poissons d'eau douce d' Europe centrale, Neuchatel, vi, 328. **42.1.**

2819. Wenckebach, K. F. Beiträge zur entwicklungsgeschichte der knochenfische. Arch. f. mikr. anat., xxviii, 225-251, taf. xvi-xvii. **86.1.**

2820. Wilson, H. V. The embryology of the sea bass. Bull. U. S. fish comm., ix, 209-277, pls. lxxxviii-cvii. **91.1.**

TENDON.

2821. Beltzow, A. Untersuchungen über entwickelung und regeneration der sehnen. Arch. f. mikr. anat., xxii, 714-738, taf. xxviiB. **83.1.**

2822. Ranvier, L. Nouvelles recherches sur la structure et le développement des tendons. Arch. de phys., vi, 181-202. **74.1.**

TERATOLOGY.

2823. Giacomini, C. Teratogenia esperimentale nei mammiferi. Giorn. accad. med., 307-330. **89.3.**

2824 ——— Sur quelques anomalies de développement de l'embryon humain. Arch. ital. biol., xvii, 99-120, 1 pl. **92.1.**

TESTIS.

2825. Benda, C. Die entwickelung des säugetierhodens. Verh. anat. ges. Berlin, iii, 125-130. **89.1.**

2826. Bramann, F. Beitrag zur lehre von dem descensus testiculorum und dem gubernaculum Hunteri des menschen. Arch. f. anat. u. phys., anat. abth., 310-340, taf. xv. **84.7.**

2827. Brazzolo, F. Ricerche sulla istologia normale e patologica del testicolo; nota ii. (La cariocinesi nel testicolo normale.) Bologna, 23 p., 1 pl. 4to. **88.1.**

2828. Etzold, F. Die entwicklung der testikel von Fringilla domestica von der winterruhe bis zum eintritt der brunst. Zeitschr. wiss. zool., lii, 46-84, taf. vi. **91.1.**

2829. Günther. Ueber das gubernaculum Hunteri. Deutsch. zeitschr. thiermed. vergl. path. Leipzig, i, 273-277. **75.1.**

2830. Hermann, F. Die postfötale histiogenese des hodens der maus bis zur pubertät. Arch. f. mikr. anat., xxxiv, 429-437, taf. xxvi. **89.2.**

2831. Klaatsch, H. Ueber den descensus testiculorum. Morph. jahrb., xvi, 587-646, taf. xxii-xxiii. **90.1.**

2832. Lockwood, E. B. Development and transition of the testis, normal and abnormal. Journ. anat. phys., xxi, 635-661, pl. xv; xxii, 36-77, pl. ii; 461-478, pl. xvii; 505-541. **87-88.2.**

2833. Mihalkowics, Victor von. Beiträge zur anatomie und histologie des hodens. Ber. sächs. ges. wiss., 217-256, taf. i-iv. **73.1.**

2834. Prenant, A. Contribution à l'histogénèse du tube séminifère. (Le tube séminifère se développe-t-il avec une ou, deux sortes de cellules?) Intern. monatsschr. f. anat. u. phys., vi, 1-30, pl. i. **89.1.**

2835. ——— Remarque à propos de la constitution de la glande génitale indifférente et de l'histogénèse du tube séminifère. C. R. soc. biol. Paris, sér. 9, ii, 192-195. **90.1.**

2836. Schmiegelow, E. Studien über die entwickelung des hodens und nebenhodens. Arch. f. anat. u. phys., anat. abth., 157-168, taf. x. **82.1.**

THYMUS AND THYROID.

2837. Afanassiew, B. Ueber die concentrischen körper der thymus. Arch. f. mikr. anat., xiv, 1-6, taf. i. **77.2.**

2838. ——— Weitere untersuchungen über den bau und die entwicklung der thymus und der winterschlafdrüse der säugethiere. Arch. f. mikr. anat., xiv, 343-390, 408, taf. xxiv. **77.1.**

2839. Born, G. Ueber die derivate der embryonalen schlundbogen und schlundspalten bei säugethieren. Arch. f. mikr. anat., xxii, 271-318, taf. x-xi. **83.1.** Abstract: Bresl. ärztl. zeitschr., iv, 282-284. **82.1.**

2840. Capobianco, F. Contribution à la morphologie du thymus. Arch. ital. biol., xvii, 55-63. **92.1.**

2841. Dohrn, A. Studien zur urgeschichte des wirbelthierkörpers; vii. Entstehung und differenzirung des zungenbein- und kiefer-apparates der selachier. viii. Die thyreoidea bei Petromyzon, Amphioxus und den tunicaten. Mitth. zool. stat. Neapel, vi, 1-92, taf. i-viii. **86.1.**

2842. ——— Studien zur urgeschichte des wirbelthierkörpers; xii. Thyreoidea and hypobranchialrinne, spritzloch-sack und pseudobranchialrinne bei fischen, Ammocoetes und tunicaten. Mitth. zool. stat. Neapel, vii, 301-337, taf. iv-v. **87.2.**

2843. Fischelis, Ph. Beiträge zur kenntniss der entwicklungsgeschichte der gl. thyreoidea und gl. thymus. Arch. f. mikr. anat., xxv, 405-440, taf. xix. **85.1.**

2844. His, Wilhelm. Schlundspalten und thymusanlage. Arch. f. anat. u. phys., anat. abth., 155-158. **89.2.**

2845. ——— Der tractus thyreoglossus und seine beziehungen zum zungenbein. Arch. f. anat. u. phys., anat. abth., 26-32. **91.1.**

2846. Kanthack, A. The thyreo-glossal duct. Journ. anat. phys., xxv, 155-165, pl. iii. **91.1.**

2847. Lustig, A. Contributo alla conoscenza della struttura della glandola tiroide fetale dell' uomo. Monitore zool. ital., ii, 13-15. **91.1.**

2848. ——— Contribution à la connaissance de l'histogenèse de la glande thyroide. Arch. ital. biol., xv, 291-295. **91.2.**

2849. Mall, F. The branchial clefts of the dog, with special reference to the origin of the thymus gland. Stud. biol. lab. Johns Hopkins univ., iv, 193-216, pls. xix-xxi. **88.2.**

2850. Maurer, F. Schilddrüse und thymus der teleostier. Morph. jahrb., xi, 129-175, pls. viii-ix. **85.1.**

2851. ——— Schilddrüse, thymus und kiemenreste der amphibien. Morph. jahrb., xiii, 296-384, taf. xi-xiii. **87.1.**

2852. Mayer, Sigmund. Zur lehre von der schilddrüse und thymus bei den amphibien. Anat. anz., iii, 97-103. **88.1.**

2853. Meuron, Pierre de. Recherches sur le développement du thymus et de la gland thyroide. Recueil zool. suisse, iii, 517-628, pls. xxiii-xxvii. **86.1.**

2854. Müller, W. Ueber die entwicklung der schilddrüse. Jen. zeitschr. f. naturw., vi, 428-453, taf. x-xii. **71.3.**

2855. ——— Ueber die hypobranchialrinne der tunicaten und deren vorhandensein bei Amphioxus und den cyclostomen. Jen. zeitschr. f. naturw., vii, 327-332. **73.1.**

2856. Retterer, E. Sur le développement des glandes vasculaires. C. R. acad. sc. Paris, c, 1596-1599. **85.1.**

2857. Stieda, Ludwig. Untersuchungen über die entwickelung der glandula thymus, glandula thyreoidea und glandula carotica. Leipzig, 2, 38 p., 2 pls. 4to. **81.1.**

2858. Streckeisen, A. Beiträge zur morphologie der schilddrüse. Virchow's Arch., ciii, 131-186, 215-243, taf. iv. **86.1.**
2859. Wölfler, A. Ueber die entwicklung und den bau der schilddrüse mit rücksicht auf die entwicklung der kröpfe. Berlin, 59 p., 7 pls. 4to. **81.1.**

TONGUE AND TASTE.

2860. Hermann, F. Beitrag zur entwicklungsgeschichte des geschmacksorgans beim kaninchen. Arch. f. mikr. anat., xxiv, 216-229, taf. xiii. **85.1.**
2861. Lustig, A. Beiträge zur kenntniss der entwickelung der geschmacksknospen. Sitzb. Wien. akad., lxxxix, abth. 3, 308-324. **84.1.**
2862. Tuckerman, F. On the development of the taste organs of man. Journ. anat. phys., xxiii, 559-582. **89.1.**
2863. ——— Further observations on the development of the taste organs of man. Journ. anat. phys., xxiv, 130-131. **89.2.**
2864. ——— On the gustatory organs of the Mammalia. Proc. Bost. soc. nat. hist., xxiv, 470-482. **89.4.**
2865. ——— On the gustatory organs of some of the Mammalia. Journ. morph., iv, 151-193. **90.2.**

TONSIL

2866. Retterer, E. Origine et évolution des amygdales chez les mammifères. Journ. anat. et phys., xxiv, 1-80, 274-360, pl. i-ii, xii-xiii. **88.1.**
2867. Schwabach. Zur entwickelung der rachentonsille. Arch. f. mikr. anat., xxxii, 187-213, taf. iv. **88.1.**
2868. Stöhr, P. Die entwicklung des adenoiden gewebes, der zungenbälge und der mandeln des menschen. Festschr. z. feier fünfzigj. doctor-jub. von Nägeli u. von Kölliker, 17 p., taf. i. **91.1.**
2869. ——— Ueber die mandeln und deren entwickelung. (Abstract.) Anat. anz., 545-548. **91.2.**

TUBAL PREGNANCY.

2870. Abel, Karl. Zur anatomie der eileiterschwangerschaft nebst bemerkungen zur entwickelung der menschlichen placenta. Arch. f. gynäk., xxxix, 393-435, taf. vii-viii. **91.1**
2871. Dobbert, Th. Beiträge zur anatomie der ektopischen schwangerschaften. Virchow's Arch., cxxiii, 103-111, taf. ii, fig. 3-4. **91.1.**

TUNICATES.

2872. Davidoff, M. v. Untersuchungen zur entwicklungsgeschichte der Distaplia magnilarvä Della Valle, einer zusammengesetzten ascidie; ii. Allgemeine entwicklungsgeschichte der keimblätter. Mitth. zool. stat. Neapel, ix, 533-650, taf. xviii-xxiv. **90.1.**
2873. Salensky, W. Beiträge zur embryonalentwickelung der pyrosomen; iii. Bildung des tetrazoiden embryos und entwicklung der ascidiozoiden. Zool. jahrb., v, abth. anat., 1-98, taf. i-viii. **91.1.**

TWINS

2874. Ahlfeld, F. Beiträge zur lehre von den zwillingen. Arch. f. gynäk., vii, 210-286; ix (1876), 196-261. **75.1.**
2875. ——— Beiträge zur lehre von den zwillingen; das verhalten der nabelbläschen bei einigen zwillingen. Arch. f. gynäk., xi, 160-172. **77.2.**
2876. Braun, M. Notiz über zwillingsbildungen bei wirbelthieren. Verh. phys.-med. ges. Würzburg, n. f., x, 67-73, taf. iii. **77.3.**
2877. Emanuel, Richard. Ueber eihautverhältnisse bei zwillingsschwangerschaft. Würzburg, 24 p. (Diss.) **87.1.**
2878. Gerlach, L. Zur bildungsgeschichte der vorderen verdoppelung. Sitzb. phys.-med. soc. Erlangen, 92-94. **86.1.**
2879. Kölliker, A. von. Ueber zwitterbildungen bei säugethieren. Sitzb. phys.-med. ges. Würzburg. **84.5.**
2880. Schatz, Friedrich. Die gefässverbindungen der placentakreisläufe einiger zwillinge, ihre entwickelung und ihre folgen. Arch. f. gynäk., xxx, 169-240, taf. ii. **87.2.**

UMBILICAL CORD.

2881. Dohrn, H. Ueber nabelschnurtorsionen. Arch. f. gynäk., xiii, 234-240. **78.1.**
2882. Köster. Ueber die feinere structur der menschlichen nabelschnur. Würzburg, 32 p., 2 pls. 4to. (Diss.) **63.1.**
2883. Lemoine, G. Anatomie générale du cordon ombilical. Lyon, 104 p., 2 pls. 4to. **84.1.**
2884. Neugebauer, L. A. Morphologie der menschlichen nabelschnur. Breslau. **58.1.**
2885. Renaut, J. Du tissu muqueux du cordon ombilical. Arch. de phys., vii, 219. **72.1.**
2886. Ruge, C. Ueber die gebilde im nabelstrang. Zeitschr. geburtsh. u. gynäk., i, 1-21. **77.1.**

2887. Ruge, C. Untersuchungen über den dottergang und über die capillaren im nabelstrang. Zeitschr. geburtsh. u. gynäk., i, 253-259. **77.2.**

2888. Sabine. Notiz über den bau der menschlichen nabelschnur. Arch. f. gynäk., ix, 311-312. **76.1.**

2889. Schott, J. A. G. Die controverse über nerven des nabelstrangs und seiner gefässe, einer sorgfältigen prüfung unterworfen. Frankfurt a. M., xviii, 122 p., 7 pls. 4to. **36.1.**

2890. Schultze, B. S. Die genetische bedeutung der velamentösen insertion des nabelstranges. Jen. zeitschr. f. naturw., iii, 198-205, 344-358. **67.1.**

2891. ——— Ueber velamentale und placentale insertion der nabelschnur. Arch. f. gynäk., xxx, 47-56. **87.1.**

2892. Simpson, J. Y. On the anatomical type of structure of the human umbilical cord and the placenta. Trans. roy. soc. Edinb., xxiii, 3-10. **65.1.**

2893. Stutz, Gustav. Der nabelstrang und dessen absterbeprocess. Arch. f. gynäk., xiii, 315-354. **78.1.**

2894. Tait, Lawson. Preliminary note on the anatomy of the umbilical cord. Proc. roy. soc. Lond., xxiv, 417-440, pl. xi-xiv. Abstract: *ibid.*, xxiii, 498-501. **76.1.**

UROGENITAL.

2895. Ackeren, F. van. Beiträge zur entwicklungsgeschichte der weiblichen sexualorgane des menschen. Zeitschr. wiss. zool., xlviii, 1-46, taf. i-iii: **89.1.**

2896. Beauregard. Contribution à l'étude du développement des organes génito-urinaires chez les mammifères. Paris, 52, iv p., 12 pls. 4to. **77.1.**

2896a. Bierfreund, Max. Ueber die einmündungsweise der Müller'schen gänge in den sinus urogenitalis bei dem menschlichen embryo. Zeitschr. geburtsh. u. gynäk., xvii, 1-12, taf. i-iv. **89.1.**

2897. Bornhaupt, Th. Untersuchungen über die entwickelung des urogenitalsystem beim hühnchen. Riga, 48 p., 3 pls. 4to. **67.1.**

2898. Borsenkow. Genitalanlage des hühnchens. Bull. soc. nat. Moscow, 11 60, taf. ii. **71.1.**

2899. Braun, M. Das urogenitalsystem der einheimischen reptilien entwicklungsgeschichtlich und anatomisch bearbeitet. Arb. zool.-zoot. inst. Würzburg, iv, 113-228, taf. v-x. **77.4.**

2900. Brock, J. Beiträge zur anatomie und histologie der geschlechtsorgane der knochenfische. Morph. jahrb., iv, 505-572, taf. xxviii-xxix. **78.1.**

2901. ——— Ueber anhangsgebilde des urogenitalapparates von knochenfischen. Z. Z., xlv, 532-541, taf. xxv. **87.1.**

2902. Cadiat, O. Du développement du canal de l'urèthre et des organes génitaux de l'embryon. Robin's Journ., xx, 242-264, pl xiii-xvi. **84.1.**

2903. Egli, Th. Beiträge zur anatomie und entwicklungsgeschichte der geschlechtsorgane. Zürich, vi, 62 p., 8vo. (Inaug. diss. univ. Basel.) **76.1.**

2904. Felix, W. Die erste anlage des exkretionssystems des hühnchens. Festschr. z. feier fünfzigj. von Nägeli, etc., Zürich, 89-122, fol. **91.1.**

2905. Franck, L. Rudimente des vorderen endes der Müller'schen gänge beim frischgeborenen hengstfohlen. Deutsch. zeitschr. thiermed. Leipzig, ix, 289. **83.1.**

2906. Fürbringer, M. Zur vergleichenden anatomie und entwicklungsgeschichte der excretionsorgane der vertebraten. Morph. jahrb., iv, i-iii, taf. i-iii. **78.1.**

2907. Gadow, H. Remarks on the cloaca and on the copulatory organs of the Amniota. Phil. trans. roy. soc. Lond., clxxviii, 5-37, pls. ii-v. **87.1.**

2908. Gasser, E. Ueber die entwicklung der allantois, der Müller'schen gänge und des afters. Abh. Senck. naturf. ges., ix, 293-368, taf. i-iii. **74.1.**

2909. ——— Beiträge zur entwicklung des urogenitalsystems der hühnerembryonen. Sitzb. Marburg. ges., 58-66. **79.2.**

2910. ——— Embryonalreste am männlichen genitalapparat. Sitzb. Marburg. ges., 74-78. **82.1.**

2911. Geigel, R. Ueber variabilität in der entwicklung der geschlechtsorgane beim menschen. Verh. phys.-med. ges., Würzburg, xvii, 129-148, taf. vi-vii. **83.1.**

2912. Hoffmann, C. K. Zur entwicklungsgeschichte der urogenitalorgane bei den Anamnia. Z. Z., xliv, 570-644, taf. i-iii. **86.1.**

2913. ——— Zur entwicklungsgeschichte der urogenitalorgane bei den reptilien. Zeitschr. wiss. zool., xlviii, 260-300, taf. xvii-xviii. **89.2.**

2914. Janosik, J. Histologisch-embryologische untersuchungen über das urogenitalsystem. Sitzb. Wien. akad., xci, abth. 3, 97-192, taf. i-iv. **85.1.**

2915. ——— Berichtigung zu Nagel's arbeit, Ueber entwickelung des urogenitalsystems des menschen. Arch. f. mikr. anat , xxxv, 104-106. **90.1.**

2916. Jüngersen, Hector F. E. Beiträge zur kenntniss der entwickelung der geschlechtsorgane bei den knochenfischen. Arb. zool.-zoot. inst. Würzburg, ix, 89-219, taf. vii-viii. **89.1.**

2917. Kobelt, G. L. Der neben-eierstock des weibes, das längst vermisste seitenstück des neben-hoden des mannes entdeckt. Heidelberg, 52 p., 3 pls. 8vo. **47.1.**

2918. Kollmann, J. Die doppelnatur des excretorischen apparates bei den cranioten. Zool. anz., v, 522-524. **82.1**.
2919. ——— Ueber die verbindungen zwischen coelom und nephridium. Festschr. z. feier 300-jähr. bestehens univ. Würzburg gewidmet von d. univ. Basel, 1-59, taf. i-ii. **82.2**.
2920. Kupffer, C. Untersuchungen über die entwicklung des harn- und geschlechtssystems. Arch. f. mikr. anat., i, 233-248, taf. xv. **65.1**.
2921. ——— Untersuchungen über die entwicklung des harn- und geschlechtssystems. Arch. f. mikr. anat., ii, 473-489, taf. xxiv. **66.1**.
2922. Langenbacher, L. Beitrag zur kenntniss der Wolff'schen und Müller'schen gänge bei säugern. Arch. f. mikr. anat., xx, 92-108, taf. vi. **82.1**.
2923. Löwe, Ludwig. Ueber die sogenannte ungestielte oder Morgagn'sche hydatide. Arch. f. mikr. anat., xvi, 15-17. **79.3**.
2924. Macbride, E. W. The development of the oviduct in the frog. Proc. Cambridge phil. soc., vii, 148-151. Q. J. M. S., xxxiii (1892), 273-281, pls. xii-xiii. **91.1**.
2925. Mihalkowics, G. von. Untersuchungen über die entwickelung des harn- und geschlechtsapparates der amnioten. (Auszug.) Intern. monatsschr. f. anat. u. phys., ii, 41-62, 65-106, 284-339, 346-385, 387-433, 435-485, taf. i-ix, ixA. **85 1**.
2926. Müller, J. Bildungsgeschichte der genitalien. Düsseldorf. **30.1**.
2927. Müller, Vitalis. Ueber die entwickelungsgeschichte und feinere anatomie der Bartholin'schen und Cowper'schen drüsen des menschen. Arch. f. mikr. anat., xxxix, 33-55, taf. ii. **92.1**.
2928. Müller, W. Ueber das urogenitalsystem des Amphioxus und der cyclostomen. Jen. zeitschr. f. naturw., ix, 94-129, taf. iv-v. **75.1**.
2929. Nagel, W. Ueber die entwickelung der sexualdrüsen und der äusseren geschlechtsteile beim menschen. Sitzb. preuss. akad. Berlin, 1027-1035. **88.3**.
2929a. ——— Ueber die entwickelung der Müller'schen gänge beim menschen. Sitzb. preuss. akad. Berlin, 15-21. **89.2**.
2930. ——— Ueber die entwickelung des urogenitalsystems des menschen. Arch. f. mikr. anat., xxxiv, 269-384, taf. xvii-xx. **89.3**.
2931. ——— Ueber die entwickelung der urethra und des dammes beim menschen. Sitzb. preuss. akad. Berlin, 829-835. **91.1**.
2932. ——— Ueber die entwickelung des uterus und der vagina beim menschen. Arch. f. mikr. anat., xxxvii, 620-654, taf. xxxv-xxxvi. **91 2**.
2933. Nicolas, A. Sur quelques détails relatifs à la morphologie des éléments épithéliaux des canalicules des corps de Wolff. C. R. soc. biol. Paris, sér. 8, v, 337-339. **88.1**.
2934. Pouchet, G. Sur le développement des organes génito-urinaires. Ann. de gynéc., vi, 179-194. **76.1**.
2935. Rathke, H. Resultate der untersuchungen über die entwickelung der geschlechtswerkzeuge der wirbelthiere. Isis, xviii, 1091-1094. **25.1**.
2936. ——— Ueber die bildung der samenleiter der Fallopischen trompete und der Gartner'schen kanäle in der gebärmutter und scheide der wiederkäuer. Meckel's Arch., xvi, 379-389. **32.1**.
2937. Regnauld, Eug. Sur l'évolution de la prostate chez le chien. C. R. soc. biol. Paris, sér. 9, iii, 521-524. **91.1**.
2938. Reichel, Paul. Die entwickelung des dammes und ihre bedeutung für die entstehung gewisser missbildungen; heft i. Zeitschr. geburtsh. u. gynäk., xiv, 82-95. **87.1**.
2939. Reichert, C. B. Ueber die Müller-Wolff'schen körper bei fischembryonen und über die sogenannten rotationen des dotters im befruchteten hechteie. Müller's Arch., 125-143, taf. iv. **56.1**.
2940. Retterer, Ed. Sur l'origine du vagin de la femme. C. R. soc. biol. Paris, sér. 9, iii, 291-293. **91.1**.
2941. ——— Sur le développement comparé du vagin et du vestibule des mammifères. C. R. soc. biol. Paris, sér. 9, iii, 312-314. **91.2**.
2942. Romiti, W. Ueber den bau und die entwicklung des eierstockes und des Wolff'schen ganges. Arch. f. mikr. anat., x 200-207, taf. xiii. **74.2**.
2943. Rosenmüller, J. C. Quaedam de ovariis embryonum et foetuum humanorum. Lipsiae, 20 p., 1 pl. 4to. **02.1**.
2944. Roth, M. Ueber einige urnierenreste beim menschen. Festschr. z. feier 300-jähr. bestehens univ. Würzburg, gewidmet von der univ. Basel, 61-87, taf. iii. **82.1**.
2945. Rouget, Ch. Évolution comparée des glandes génitals mâles et femelles chez les embryons de mammifères. C. R. acad. sc. Paris, lxxxviii, 602-604. **79.2**.
2946. Rückert, Johannes. Ueber die entstehung der exkretionsorgane bei selachiern. Arch. f. anat. u. phys., anat. abth., 205-278, taf. xiv-xvi. **88.1**.
2947. ——— Zur entwicklung des excretionssystems der selachier; eine erwiderung an Herrn van Wijhe. Zool. anz., xii, 15-22. **89.1**.
2948. Salvioli, I. Contribution à la physiologie des épithéliums; de la structure de l'épithélium vaginal de la lapine et des modifications qu'il subit pendant la gestation. Arch. ital. biol., xvii, 35-45. **92.1**.
2949. Schoof, Ferdinand. Zur kenntniss des urogenitalsystems der saurier. Arch. f. naturgesch., jahrg. 54, bd. i, 62-80, taf. iii. **88.1**.

2950. Sedgwick, A. On the early development of the anterior part of the Wolffian duct and body in the chick, together with some remarks on the excretory system of the Vertebrata. Q. J. M. S., xxi, 432-468, pl. xxvi. **81.1.**

2951. Semon, R. Die indifferente anlage der keimdrüsen beim hühnchen und ihre differenzierung zum hoden. Jen. zeitschr. f. naturw., xxi, 46-80, taf. v. **87.1.**

2952. ——— Studien über den bauplan des urogenitalsystems der wirbelthiere, dargelegt an der entwickelung dieses organsystemes bei Ichthyophis glutinosus. Jen. zeitschr. f. naturw., xxvi, 89-203, taf. i-xiv. **91.1.**

2953. Semper, C. Das urogenitalsystem der plagiostomen, und seine bedeutung für das der übrigen wirbelthiere. Arb. zool.-zoot. inst. Würzburg, ii, 195-309, taf. x-xxii. **75.2.**

2954. Sernoff, D. Zur frage über die entwicklung der samenröhren des hodens, und der Müller'schen gänge. Centralbl. f. med. wiss., xii, 481-483. **74.1.**

2955. Spengel, J. W. Das urogenitalsystem der amphibien: 1. Der anatomische bau des urogenital systems. Arb. zool.-zoot. inst. Würzburg, iii, 1-114, taf. i-iv. **76.3.**

2956. Thiersch. Bildungsfehler der harn- und geschlechtsorgane. Illustr. med. zeit., i. **52.1.**

2957. Tourneux, F. Sur la participation des canaux de Wolff à la constitution de l'extrémité inférieure (ou postérieure) du vagin chez le foetus de cheval. C. R. soc. biol. Paris, sér. 8, v, 379-381. **88.2.**

2958. ——— L'organe de Rosenmüller (époophore) et le parovarium (paroophore) chez les mammifères. Journ. anat. et phys., xxiv, 169-192, pl. viii. **88.3.**

2959. ——— Sur le développement du vagin mâle (utricule prostatique) chez le foetus humain. Revue biol. nord France, Lille, i, 212-219. **89.2.** Preliminary notice. C. R. soc. biol. Paris, sér. 8, iv, 807-812. **87.1.**

2960. Vialleton, L. Développement postembryonnaire du rein de l'ammocète. C. R. acad. sc. Paris, cxi, 399-401. **90.1.**

2961. Watson, M. The homology of the sexual organs, illustrated by comparative anatomy and pathology. Journ. anat. phys., xiv, 50-80, pls iii-iv. **79.1.**

2962. Weber, E. H. Zusätze zur lehre vom bane und von den verrichtungen der geschlechtsorgane. Müller's Arch., 421-428. Abh. sächs. ges. wiss., 200-jähr. geburtstags-feier Leibnizen's, Leipzig, 381-459, taf. i-ix. **46.1.**

2963. Weiss, F. E. Excretory tubules in Amphioxus lanceolatus. Q. J. M. S., xxxi, 489-497, pls. xxxiv-xxxv. **90.1.**

2964. Wiedersheim, R. Ueber die entwickelung des urogenitalapparates bei krokodilen und schildkröten. Arch. f. mikr. anat., xxxvi, 410-482, taf. xvi-xviii. Preliminary notice: Anat. anz., v. 337-344. **90.3**

2965. Wieger, G. Ueber die entstehung und entwickelung der bänder des weiblichen genitalapparates beim menschen; ein beitrag zur lehre des descensus ovariorum. Arch. f. anat. u. phys., anat. abth., 349-360. **85.1.**

2966. Wijhe, J. W. van. Ueber die mesodermsegmente des rumpfes und die entwicklung des exkretionssystems bei selachiern. Arch. f. mikr. anat., xxxiii, 461-516, taf. xxx-xxxii. **89.1.**

2967. Wittich. Beiträge zur morphologischen und histologischen entwickelung der harn- und geschlechtswerkzeuge der nackten amphibien. Z. Z., iv, 125-167, taf. ix-x. **53.1.**

UTERUS

2968. Acconci, L. Contributo allo studio dell' anatomia e fisiologia dell' utero gestande e partoriente. Giorn. accad. Torino, liii, 641. Abstract: Monitore zool. ital., i, 217. **90.1.**

2969. ——— Contribution à l'étude de l'anatomie et de la physiologie de l'utérus gravide. Arch. de tocol. Paris, xvii, 794-804. **90.2.**

2970. Blanc, Emile. Recherches histologiques sur la structure du segment inférieur de l'utérus à la fin de la grossesse. Arch. de phys., xx, 265-291, pl. vii. **88.1.**

2971. Bonnet, R. Die uterinmilch und ihre bedeutung für die frucht. Beitr. z. biol., Bischoff's festgabe, Stuttgart, 221, 263, 1 taf. **82.1.**

2972. Cadiat, O. Mémoire sur l'utérus et les trompes. Robin's Journ., xx, 409-431, pls. xxvi-xxix. **84.2.**

2973. Cleland, J. Later foetal development of the vagina and uterus in the human subject. Mem. and memoranda in anat., London, i, 166-168. **89.1.**

2974. Coblenz, H. Zur entwicklungsgeschichte der inneren weiblichen sexualorgane beim menschen, im zusammenhange mit pathologischen vorgängen. Zeitschr. f. ges. naturw., f. 3, vi, 313-329, taf. ii. **81.1.**

2975. Delaunay, G. La fécondité. Revue scient., sér. 3, x, 433-437, 466-470. **85.1.**

2976. Dohrn, F. A. R. Zur kenntniss der Müller'schen gänge und ihrer verschmelzung. Schrift. Marburg. ges., ix, 251-259, 3 pls. **71.1.**

2977. ——— Ueber die entwickelung des hymens. Schrift. Marburg. ges., x, suppl., heft i, 8 p., 10 pls. **75.1.**

2978. ——— Ueber die Müller'schen gänge und die entwicklung des uterus. Monatsschr. f. geburtsh., xxxiv, 382-384. **96.1.**

2979. Duval, M. De la régénération de l'épithélium des cornes utérines après la parturition. C. R. soc. biol. Paris, sér. 9, ii, 697-698. **90.3.**

2980. Elischer, J. Beiträge zur feineren anatomie der muskelfasern des uterus. Arch. f. gynäk., ix, 10-21, taf. ii. **76.1.**

2981. Farre, A. Uterus and its appendages. Todd's Cyclopaedia anat. phys. v, 545-725. **58.1.**

2982. Friedländer, Carl. Ueber die innenfläche des uterus post partum. Arch. f. gynäk., ix, 22-28. **76.1**.
2983. Gasser. Ueber entwicklung der Müller'schen gänge. Sitzb. Marburg. ges., 1-3. **72.1**.
2984. Gottschalk. Ein uterus gravidus aus der fünften woche der lebenden entnommen. Arch. f. gynäk., xxix, 488-510, taf. ix. **87.1**.
2985. Helme, Arthur. Histological observations on the muscular fibre and connective tissue of the uterus during the pregnancy and the puerperium. Trans. roy. soc. Edinb., xxxv, 359-376, 1 pl. **90.1**.
2986. Hofmeier, M. Das untere uterinsegment in anatomischer und physiologischer beziehung. Schröder, no. 908, 21-73. **86.1**.
2987. Hunter, William. An anatomical description of the human gravid uterus and its contents. London, 88 p., 8vo. **1794.1**.
2988. Imbert, G. Développement de l'utérus et du vagin. Lyon, 111 p., 4to. (Thèse.) **83.1**.
2989. ——— Le col et le segment inférieur de l'utérus à la fin de la grossesse; documents anatomiques. Paris, 79 p. **87.1**.
2990. Johnstone. On the menstruation organ. Discussion. Brit. gynec. journ., pt. vii, 292-301, 301-307. **86.1**.
2991. Kahlden, C. Ueber das verhalten der uterusschleimhaut während und nach der menstruation. Beitr. z. geburtsh. u. gynäk. Stüttgart, 107-138, 1 taf. **89.1**.
2992. Klein, G. Entwickelung und rückbildung. Zeitschr. f. geburtsh. u. gynäk. Stüttgart, xxii, 247-295, taf. i. **91.1**.
2993. Küstner, Otto. Das untere uterinsegment und die decidua cervicalis. 8vo., 2 pls. **82.1**.
2994. Kundrat, Hanns, *and* Engelmann, G. J. Untersuchungen über die uterusschleimhaut. Stricker's Med. jahrb., 135-177, taf. i. **73.1**.
2995. Legay, Ch. G. Développement de l'utérus jusqu'à la naissance. Lille, 43 p., pl. i, 4to. (Thèse.) **84.1**.
2996. Leopold, G. Die lymphgefässe des normalen nichtschwangeren uterus. Arch. f. gynäk., vi, 1-54, taf. i-iii. **74.1**.
2997. Löwenthal, W. Eine neue deutung des menstrualprocesses. Arch. f. gynäk., xxiv, 168-261. Abstract: Centralbl. f. gynäk., 306-312. **85.1**.
2998. Lombardini, L. Sull' utero di cavalla nei primi mesi della gravidanza: osservazioni anatomiche. Giorn. anat. fis. path. animali, Pisa, xvii, 181-199, 301-318, tav. i-ii. **85.1**.
2999. Mayor, A. Étude histologique sur l'involution utérine. Arch. de phys., Paris, sér. 3, x, 560-579, pl. i. **87.1**.
3000. Meola, F. La involuzione dell' utero studiata dall' aspetto istologico; nota preventiva. Il Morgagni, Napoli, xxvi, 25, 238, 1 pl. **84.2**.
3001. Müller, H. Abhandlung über den bau der molen. Würzburg, 87 p. **47.1**.
3002. Nagel, W. Ueber die entwickelung des uterus und der vagina beim menschen. Sitzb. preuss. akad. Berlin, 547-552. **90.1**.
3003. ——— Ueber die lage des uterus im menschlichen embryo. Arch. f. gynäk., xli, 244-258, taf. x. **91.3**.
3004. Parker, T. J. On the gravid uterus of Mustelus antarcticus. Trans. New Zealand inst., xv, 219-222, pl. xxx. **82.1**.
3005. Paschen, D. Beschreibung eines graviden uterus aus dem fünften monat der schwangerschaft. Marburg, 19 p. (Diss.) **87.1**.
3006. Pateuko, T. Ueber die nervenendigungen in der uterinschleimhaut des menschen; vorläuf. mittheilung. Centralbl. f. gynäk., iv, 442-444. **80.1**.
3007. Remmett, A. A. Beitrag zur lehre von der entwicklung der gebärmutter und scheide. Med. sbornik, Tiflis, xxiv, 1-56, taf. iii. **87.1**.
3008. Romiti, G. Sull' anatomia dell' utero gravido. Monitore zool. ital., i, 15-16. Translation: Arch. ital. biol., xiii, 358-360. **90.1**.
3009. ——— Sull' anatomia dell' utero gravido; nota 2ª. Monitore zool. ital., ii, 21-29. Translation: Arch. ital. biol., xv, 254-261. **91.1**.
3010. Sinéty, de. Sur l'histologie normale de la cavité utérine quelques heures après l'accouchement. C. R. soc. biol. Paris. Ann. gynéc., vi, 217-220. **76.1**.
3011. ——— Étude histologique sur la cavité utérine après la parturition. Arch. phys. norm. path., sér. 2, iii, 342-352. **76.2**.
3012. Sobatta, J. Beiträge zur vergleichenden anatomie und entwickelungsgeschichte der uterusmuskulatur. Arch. f. mikr. anat., xxxviii, 52-100, taf. iv. **91.1**.
3013. Tourneux, F., *and* Legay, Ch. Mémoire sur le développement de l'utérus et du vagin envisagé principalement chez le foetus humain. Robin's Journ., xx, 330-386, pl. xx-xxv. **84.1**.
3014. Underhill. Note on the uterine mucous membrane of a woman who died immediately after menstruation. Edinb. med. journ., xxi, 132-133. **75.1**.
3015. Varnier, N. H. Le col et le segment inférieur de l'utérus à la fin de la grossesse pendant et après le travail de l'accouchement. Ann. gynéc. Paris, xxviii, 40-67, 354-374. **87.1**.
3016. Waldeyer, W. Medianschnitt einer hochschwangeren bei steisslage des foetus, nebst bemerkungen über die lage und formverhältnisse des uterus gravidus nach längs- und querschnitten. Bonn, atlas, 5 taf. **86.1**.
3017. ——— Ueber die lage der inneren weiblichen geschlechtsorgane. Sitzb. preuss. akad. Berlin, xxviii, 1019-1025. **88.2**.

3018. Werth. Beiträge zur anatomie, physiologie und pathologie der menschlichen schwangerschaft; i. Ueber die sogenannte uterinmilch des menschen. Arch. f. gynäk., xxii, 233-249. **84.1**.

3019. Williams, J. On the structure of the mucous membrane of the uterus and its periodical changes. Obstetr. journ. Gt. Brit. Ireland, ii, 681-696, pl. i, 753-767, pl. ii-iii. **75.1**.

3020. ——— The mucous membrane of the body of the uterus. Obstetr. journ. Gt. Brit. Ireland, iii, 496-504. **75.2**.

3021. Wyder, Aloys Theodor. Beiträge zur normalen und pathologischen histologie der menschlichen uterusschleimhaut; i. Die mucosa uteri der kinder; ii. Menstruation endometritis; iii. Dysmenorrhea membranacea. Arch. f. gynäk., xiii, 1-55, taf. i. **78.1**.

VEINS.

3022. Hochstetter, F. Beiträge zur vergleichenden anatomie und entwicklungsgeschichte des venensystems der amphibien und fische. Morph. jahrb., xiii, 119-172, taf. i-iv. **87.1**.

3023. ——— Ueber die entwicklung der extremitätsvenen bei den amnioten. Morph. jahrb., xvii 1-43, taf. i-iii. **91.1**

3024. ——— Ueber den einfluss der entwickelung der bleibenden nieren auf die lage des urnierenabschnittes der hintern cardinalvenen. Anat. anz., iii, 938-940. **88.2**.

3025. Marshall, J. On the development of the great anterior veins in man and Mammalia, including an account of certain remnants of foetal structure found in the adult, a comparative view of these great veins in the different Mammalia, and an analysis of their occasional peculiarities in the human subject. Phil. trans. roy. soc. Lond., 133-170, pl. i-iv. **50.1**.

3026. Phisalix, C. Mécanisme de certaines transformations dans la circulation véneuse de l'embryon humain. Verh. X. intern. med. kongress Berlin, ii, abth. i, anat., 89-93. **91.1**.

3027. Rathke, H. Ueber die bildung der pfortader und der lebernerven bei säugethieren. Meckel's Arch., 434-438. **30.1**.

3028. ——— Ueber die früheste form und die entwicklung des venensystems und der lungen beim schafe. Meckel's Arch., 63-73, taf. i. **30.2**.

3029. Rex, Hugo. Beiträge zur morphologie der hirnvenen der elasmobranchier. Morph. jahrb., xvii, 417-466, taf. xxv-xxvii. **91.1**.

3030. Robinson, A. Abnormalities of the venous system and their relation to the development of veins. Stud. anat., anat. dep. Owens coll., i, 197-208, pl. vi. **91.2**.

VERTEBRATES.

3031. Balfour, F. M. A comparison of the early stages in the development of vertebrates. Q. J. M. S., xv, 207-226, pl. x. **75.2**.

3032. Goette, Alex. Zur entwicklungsgeschichte der wirbelthiere. Centralbl. f. med. wiss., vii, 404-406. **69.1**.

3033. Hensen, V. Embryologische mittheilungen. Arch. f. mikr. anat., iii, 500-503. **67.1**.

3034. His, Wilhelm. Zur frage der längsverwachsung von wirbeltierembryonen. Verh. anat. ges., v, 70-83. **91.2**.

3035. Kollmann, J. Gemeinsame entwicklungsbahnen der wirbelthiere. Arch. f. anat. u. phys., anat. abth., 279-306, taf. xii. **85.1**.

3036. ——— Ueber gemeinsame entwicklungsbahnen der wirbelthiere. Zeitschr. wiss. zool., xli, 517-524. **85.2**.

3037. Kupffer, C. Die gastrulation an den meroblastischen eiern der wirbelthiere und die bedeutung des primitivstreifens. Arch. f. anat. u. phys., anat. abth., 1-28, 139-154, taf. i-iv, viii-ix. **82.2**.

3038. ——— Die gastrulation an den meroblastischen eiern der wirbelthiere und die bedeutung des primitivstreifs. Arch. f. anat. u. phys., anat. abth., 1-40, taf. i-ii. **84.1**.

3039. Schneider, A. Studien zur systematik und zur vergleichenden anatomie, entwicklungsgeschichte und histologie der wirbelthiere. Zool. beitr., ii, 268-270, taf. xxiii-xxvii. **90.2**.

WOLFFIAN BODY.

3040. Banks, W. M. On the Wolffian bodies of the foetus and their remains in the adult, including the development of the generative system. Edinburg, 103 p. 6 pls. **64.1**.

3041 Beard, J. The origin of the segmental duct in elasmobranchs. Anat. anz., ii, 646-652. **87.1**.

3042. Beigel, Hermann. Zur entwicklungsgeschichte des Wolffschen körpers beim menschen. Centralbl. f. med. wiss., 481-482. **78.2**.

3043. Bonnet, R. Ueber die ektodermale entstehung des Wolff'schen ganges bei den säugethieren. München. med. wochenschr., xxxiv, 579-581. **87.1**.

3044 Clarke, S. F. The early development of the Wolffian body in Amblystoma punctata. Stud. biol. lab. Johns Hopkins univ., ii, 39-44, pl. i-iii. **81.1**.

3045. Czerny, Adalbert. Das Giraldes'sche organ, nach untersuchungen an kaninchen, hunden und katzen. Arch. f. mikr. anat., xxxiii, 445-461, taf. xxviii-xxix. **89.1**.

3046. Dohrn, H. Ueber die Gärtner'schen kanäle beim weibe. Arch. f. gynäk., xxi, 328-345. **83.2**.
3047. Dursy. Ueber den bau der urniere des menschen und der säugethiere. Zeitschr. f. rat. med., r. 3, xxiii, 257-263. **65.1**.
3048. Flemming, Walther. Die ektoblastische anlage des urogenitalsystems beim kaninchen. Arch. f. anat. u. phys., anat. abth., 236-248, taf. xi. **86 1**.
3049. Gasser, E. Ueber die entstehung des Wolff'schen ganges beim huhn. Sitzb. Marburg. ges., 21-23. **75.1**.
3050. ——— Beobachtungen über die entstehung des Wolff'schen ganges bei embryonen von hühnern und gänsen. Arch. f. mikr. anat., xiv, 442-459. **77 2**.
3051. ——— Ueber das obere ende des Wolff'schen ganges und die primäre urnierenanlage. Sitzb. Marburg. ges., 62-65. **78.1**.
3052. Giraldès, J. A. Recherches anatomiques sur le corps innominé. Journ. anat. et phys., Paris, iv, 1-8. pl. i-v. **61.1**.
3053. Haddon, A. C. Suggestion respecting the epiblastic origin of segmental duct. Sc. proc. roy. soc. Dublin, n. s., v, 463-472. pl. x. **87.1**.
3054. Jacobson, L. L. Die Oken'schen körper oder die primordialnieren. Kjöbenhavn, 26 p., 2 pls. 4to. **30.1**.
3055. Koch. Ueber die Gärtner'schen gänge beim weibe. Arch. f. gynäk, xx, 487-491. **82.1**.
3056. Lenckart, Rudolph. Das Weber'sche organ und seine metamorphosen. Illustr. med. zeitschr. München, i, 69-98. **52.1**.
3057. Martin, E. Ueber die anlage der urniere beim kaninchen. Arch. f. anat. u. phys., anat. abth., 109-123, taf. vii. **88.1**.
3058. Meyer, Hans. Die entwickelung der urnieren beim menschen. Arch. f. mikr. anat., xxxvi, 138-172, taf. v-vi. **90.1**.
3059. Mitsukuri, K. The ectoblastic origin of the Wolffian duct in Chelonia. Preliminary notice. Zool. anz., xi, 111. **88.1**.
3060. Perényi, von. Die ektoblastische anlage des urogenitalsystems bei Rana esculenta und Lacerta viridis. Vorläuf. mittheilung. Zool. anz., x, 66. **87.1**.
3061. Renson, G. Recherches sur le rein céphalique et le corps de Wolff chez les oiseaux et les mammifères. Extrait. Arch. f. mikr. anat., xxii, 599-608. **83.1**.
3062. Roth, M Ueber einige urnierenreste beim menschen. Festschr. 300-jahr. best. Jul. Max. univ. Würzburg, 64-87, 1 taf. **82.1**.
3063. Sedgwick, A. On the development of the structure known as the glomerulus of the head-kidney. Stud. morph. lab. univ. Cambridge. Q. J. M. S., xx, 372-374. **80 2**.
3064. Semon, Richard. Ueber die morphologische bedeutung der urniere in ihrem verhältniss zur vorniere und nebenniere und über ihre verbindung mit dem genitalsystem. Anat. anz., v, 455-482. **90.1**.
3065. Spee, F. Ueber directe betheiligung des ektoderms an der bildung der urnierenanlage des meerschweinchens. Arch. f. anat. u. phys., anat. abth., 89-102, taf. v. **84.1**.
3066. Strahl, H. [Ueber den Wolff'schen gang und die segmentalbläschen bei Lacerta.] [Anlage des Wolff'schen ganges beim kaninchen.] Sitzb. Marburg. ges., 43-46, 47, 48. **86.1**.
3067. Weldon, W. F. R. On the head kidney of Bdellostoma, with a suggestion as to the origin of the suprarenal bodies. Q. J. M. S., xxiv, 171-182, pls. xv. **84.3**.

YOLK SAC.

3068. Ahlfeld, F. Ueber die persisteuz des dotterstrangs in der nabelschnur. Arch. f. gynäk., ix, 325. **76.1**.
3069. ——— Ueber die persistenz der dottergefässe, nebst bemerkungen über die anatomie des dotterstranges. Arch. f. gynäk., xi, 184-197. **77.1**.
3070. Allen, W. Omphalo-mesenteric remains in mammals. Journ. anat. phys., xvii, 59-61. **83.1**.
3071. Hansen, J. A. Ein beitrag zur persistenz des ductus omphalo-entericus. Kiel, 21 p. 8vo. **85.1**.
3072. Kleinwächter. Ein beitrag zur anatomie des ductus omphalo-mesentericus. Arch. f. gynäk., x, 238-247, taf. vii. **76.1**.
3073. Robinson, A. The nutritive importance of the yolk sac. Journ. anat. phys., xxvi, 308-323, pl. viii. **92.2**.
3074. Ryder, J. A. The functions and histology of the yolk-sack of the young toad fish. Proc. acad. nat. sc. Philadelphia, 1890, 407-408. **91.1**.
3075. Schenk, S. Der dotterstrang der plagiostomen. Sitzb. Wien. akad., lxix, 301-308, taf. i. **74.1**.
3076. Schultze, B. S. Das nabelbläschen ein constantes gebilde in der nachgeburt des ausgetragenen kindes. Leipzig. **61.1**.
3077. Strahl, H. Ueber den parablast der eidechse. Sitzb. Marburg. ges., 16-18. **85.1**.
3078. ——— Die dottersackwand und der parablast der eidechse. Zeitschr. wiss. zool., lxv, 282-307, taf. xvi. **87.1**.
3079. Tourneux, F. Note sur l'épithélium de la vésicule ombilicale chez l'embryon humain. C. R. soc. biol. Paris, sér. 9, i, 197-200. **89.3**.
3080. Virchow, Hans. Ueber das epithel des dottersackes im hühnerei. Berlin, 29 p., 1 pl. 8vo. (Inaug. diss.) **75.1**.
3081. ——— Beobachtungen am hühnerei über das dritte keimblatt im bereiche des dottersacks. Arch. f. path. anat., lxii, 566-568. **76.1**.
3082. ——— Der dottersack des huhnes. Intern. beitr. z. wiss. med., i, festschr. R. Virchow, taf. x-xiv. Reprint, 129 p. **91.1**.

ADDENDA.

SUBJECT INDEX.

Amnion 3083
Amphibia 3084-3088
Amphioxus 3089-3094
Annelids 3095
Anus 3096
Aorta 3097-3099
Arteries 3100-3103

Birds 3104-3107
Birth 3108-3109
Blood 3110-3122
Blood vessels 3123-3131
Bone 3132-3133
Brain 3134-3145

Cells 3146
Cell division 3147-3155
Cell theory 3156-3160
Cerebellum 3161-3162
Coelom 3163-3164
Conjugation 3165
Connective tissue 3166-3167

Decidua 3168-3169

Ear 3170-3178
Ear external 3179
Elasmobranchs 3180-3181
Elastic tissue 3182
Electric organ 3183
Epidermis 3184-3186
Epiphysis 3187
Evolution 3188-3191
Eye 3192-3202

Face 3203
Foetal envelopes 3204

Ganglia 3205-3206
Ganoids 3207
General works 3208-3211
Genitalia external 3212-3214
Germ layers 3215-3227
Gestation 3228
Gills 3229
Growth 3230

Hairs 3231-3233
Head 3234-3236
Heart 3237-3239
Hemispheres, Cerebral 3239A-3244
Heredity 3245-3257
Human embryo 3258-3260
Hypophysis 3261-3262

Impregnation 3263-3266
Intestine 3267-3283

Jacobson's organ 3284-3285

Larynx 3286
Lateral line 3287-3289
Limbs 3290-3293
Liver 3294-3301
Lung 3302

Mammae 3303
Mammals 3304-3310
Marsipobranchs 3311-3313
Medullary nerve cells 3314-3315
Mesentery 3316-3317
Metamerism 3318-3322
Muscles 3323-3328

Nerves 3329-3331
Nerves, Cephalic 3332-3339
Nervous tissue 3340-3346
Neuroglia 3347
Neuromeres 3348
Neuron 3349
Nose 3350-3352
Notochord 3353-3354
Nuclei 3355-3356

Olfactory lobes 3357-3358
Ovary 3359-3362
Ovulation 3363-3365
Ovum 3366-3372

Pancreas 3373-3377
Parthenogenesis 3378-3379
Pigment cells 3380

Pineal gland 3381-3382
Placenta 3383-3395
Polar globules 3396-3397
Pregnancy 3398
Primates 3399-3401
Protoplasm 3402

Reptiles 3403-3411
Retina 3412-3414
Rodents 3415

Segmental organs 3416
Segmentation 3417-3426
Sex 3427-3429
Sexuality 3430
Skeleton 3431-3435
Skull 3436-3442
Spermatogenesis 3443-3449
Spermatozoa 3450-3453
Spleen 3454-3456
Spinal cord 3457
Stomach 3458-3459
Supra-renals 3460-3462
Sympathetic 3463-3465

Teeth 3466-3487
Teleosts 3488-3490
Teratology 3491-3500
Testis 3501-3502
Text-books 3503-3507
Thymus and thyroid 3508-3513
Tongue and taste 3514-3515
Touch 3516
Tunicates 3517

Umbilical cord 3518
Urogenital 3519-3524
Uterus 3525

Veins 3526-3530
Vertebrae 3531-3543
Vertebrates 3544

Wolffian body 3545-3548

Yolk sac 3549-3555

AMNION.

3083. Marotta, A. Studi sulla struttura dell' amnios del gatto. Atti accad. sc. fis. e mat. (soc. reale) Napoli, ser. 2, 1, appendice 2, 8 p., tav. ii, iii. **88.1**.

AMPHIBIA.

3084. Houssay, F. Études d'embryologie sur les vertébrés; développement et morphologie du parablast et de l'appareil circulatoire. Arch. zool. expér., sér. 3, i, 1-94, pl. i-v. **93 1**.

3085. Jordan, E. O. The habits and development of the newt. Journ. morph., viii, 269-366, pls. xiv-xviii. **93.1**.

3086. Kingsley, J. S. The head of an embryo Amphiuma. Am. nat., xxvi, 671-680. **92 1**.

3087. Morgan, T. H. Some notes on the breeding habits and embryology of frogs. Am. nat., xxv, 753-760. **91.2**.

3088. Wyman, J. Observations on the development of the Surinam toad (Pipa americana.) Am. journ. sc., xvii, 369-374. Proc. Bost. soc. nat. hist., v, 13-14. **54.1**.

AMPHIOXUS.

3089. Boveri, Th. Ueber die niere des Amphioxus. München. med. wochenschr., xxxvii, 452-455. **90.2.**
3090. Lwoff, Basilius. Ueber einige wichtige punkte in der entwickelung des Amphioxus. Biol. centralbl., xii, 729-744. **92.1.**
3091. ———— Ueber den zusammenhang von markrohr und chorda beim Amphioxus und ähnliche verhältnisse bei anneliden. Zeitschr. wiss. zool., lvi, 299-309, taf. xvii. **93.2.**
3092. Schultze, M. Beobachtung junger exemplare von Amphioxus. Zeitschr. wiss. zool., iii, 416-419, taf. xiii. **51.2.**
3093. Wijhe, J. W. van. Ueber Amphioxus. Anat. anz., viii, 152-172. **93.1.**
3094. Wilson, E. B. On multiple and partial development in Amphioxus. Anat. anz., vii, 732-740. **92.1.**

ANNELIDS.

3095. Wilson, E. B. The cell-lineage of Nereis; a contribution to the cytogeny of the annelid body. Journ. morph., vi, 361-480, pls. xiii-xx. **92.2.**

ANUS.

3096. Tourneux, F. Sur le mode de formation du périnée chez l'embryon du mouton par abaissement d'un repli périnéal unique. C. R. soc. biol. Paris, sér. 9, ii, 75-77. **90.1.**

AORTA.

3097. Key-Aberg, Algot. Ueber den bau der tunica intima der aortenwand bei dem erwachsenen menschen. Retzius's Biol. untersuch., 27-50, taf. iii-v. **81.1.**
3098. Picchini, L. Sviluppo dell' arteria polmonare e dell' aorta; rapporto tra il diametro dell' uno e dell' altro vaso. Il Morgagni, Napoli, xxxiii, 779-783. **91.1.**
3099. Vialleton, L. Développement des aortes chez l'embryon de poulet. Journ. anat. et phys., xxviii, 1-27, pls. i-ii. **92.1.**

ARTERIES.

3100. Aschoff, Al. Beitrag zur entwickelungsgeschichte der arterien beim menschlichen embryo. Morph. arb., ii, 1-35, taf. i-iii. **92.1.**
3101. Bayer, L. Beitrag zur vergleichenden anatomie der oberarmarterien. Morph. jahrb., xix, 1-41, taf. i. **92.1.**
3102. Davenport, C. B. Note on the carotids and the ductus botalli of the alligator. Bull. mus. comp. zool., xxiv, 45-48, 1 pl. **93.1.**
3103. Eichholz, Alfred. Morphology of the limb arteries in vertebrates with especial reference to the disposition in the human subject. Journ. anat. phys., xxvii, 377-401. **93.1.**

BIRDS.

3104. Blanc, Louis. Note sur l'influence de la lumière sur l'orientation de l'embryon dans l'oeuf de poule. C. R. soc. biol. Paris, sér. 9, iv, 774-776. **92.1.**
3105. Dareste, C. Note sur l'évolution de l'embryon de la poule soumis pendant l'incubation à un mouvement de rotation continu. C. R. acad. sc. Paris, cxv, 137-138. **92.1.**
3106. Parker, T. J. Observations on the anatomy and development of Apteryx. Phil. trans. roy. soc. Lond., clxxxii, 25-134, pls. iii-xix. **91.2.**
3107. Tredern, L. S. G. von. Ovi avium historiae et incubationis prodromus. Jena, 16 p., 1 pl. 4to. (Inaug. diss.) **03.1.**

BIRTH.

3108. Knüpffer, W. Ueber die ursache des geburtseintrittes auf grundlage vergleichend anatomischer untersuchungen. Dorpat, 46 p., 2 pls. 4to. (Inaug. diss.) **92.1.**
3109. Lang, Gustave. Note pour servir à l'histoire des rapports entre la menstruation et le développement du foetus à terme. Arch. tocol. et gynéc., xix, 743-749. **92.1.**

BLOOD.

3110. Cuénot, L. Études sur le sang et les glandes lymphatiques dans la série animale. Arch. zool. expér., sér. 2, ix, 13-90, 365-475, 593-670, pls. i-iv, xv-xviii, xxiii. **91.1.**
3111. Kostanecki, K.v. Die embryonale leber in ihrer beziehung zur blutbildung. Anat. hefte, iii, abth. 1, 301-322. **92.2.**

3112. Luzet, Charles. Étude sur la régénération du sang après saignée chez les oiseaux (l'érythrocyte et l'hématoblaste). Arch. phys. norm path , sér. 5, iii, 455-468, pl. v. **91.1**.

3113. Mix, C. L. Origin of the red blood corpuscles. Bost. med. surg. journ., cxxvi, 255-258, 283-286. **92.1**.

3114. Nusbaum, J. Beitrag zur kenntnis der entwicklung der ersten embryonalen lebergefässe und deren blutkörperchen. Biol. centralbl., xiii, 356-359. **93 2**.

3115. Sanfelice, F. Genesi dei corpuscoli rossi nel midollo delle ossa dei vertebrati. Boll. soc. nat. Napoli, ser. 1, iii, 143-168. **89 1**.

3116. Schmidt, M. B. Ueber blutzellenbildung in leber und milz unter normalen und pathologischen verhältnissen. Beitr. path. anat. u. allg. path. Jena, xi, 199-233. **92.1**.

3117. Spuler, A. Ueber die intracelluläre entstehung rother blutkörperchen. Arch. f. mikr. anat., xl, 530-552, taf. xxxi. **92.1**.

3118. Stricht, O. van der. Le développement du sang dans le foie embryonnaire. Arch. de biol., xi, 19-113, pls. i-ii. **91.1**.

3119. ——— Division mitosique des érythroblastes et des leucoblastes à l'intérieur du foie embryonnaire des mammifères. Anat. anz., vi, 591-594. **91.2**.

3120. ——— Nouvelles recherches sur la genèse des globules rouges et des globules blancs du sang. Arch. de biol., xii, 199-344, pls. vii-xii. **92.1**.

3121. Toupet *and* Ségall. Contribution à l'étude du développement des vaisseaux dans l'épiploon des embryons de cobayes. C. R. soc. biol. Paris, sér. 9, iv, 737-738. **92.1**.

3122. Ziegler, H. E. Ueber die embryonale anlage des blutes bei den wirbeltieren. Verh. deutsch. zool. ges., 2. vers. Berlin, 18-30. **92.1**.

BLOOD VESSELS.

3123. Eberth, C. J. Ueber den bau und die entwicklung der blutcapillaren; i. Ueber den bau der blutcapillaren der wirbelthiere. Würzburg. naturw. zeitschr., vi, 27-32, taf. iii-iv. **65.1**.

3124. ——— Ueber den bau und die entwicklung der blutcapillaren; ii. Ueber die blutbahnen der wirbellosen thiere. Würzburg. naturw. zeitschr., vi, 84-109, taf. vi-vii. **66.1**.

3125. Houssay, F. Sur la circulation embryonnaire dans la tête chez l'axolotl. C. R. acad. sc. Paris, cxv, 132-135. **92.1**.

3126. Janosik, J. Le développement des vaisseaux sanguins et des nerfs du membre antérieur chez l'homme et chez quelques autres animaux. Sborn. lék. Praze, iv, 244-255, 1 pl. **91.1**.

3127. Macdonald, W. On foetal circulation. Edinburg, 44 p., 2 col. pls. 8vo. **68.1**.

3128. Raffaele, F. A. Ricerche sullo sviluppo del sistema vascolare nei selacei. Mittth. zool. stat. Neapel, x, 441-479, tav. xxix-xxxi. **92.1**.

3129. Spencer, W. Baldwin. Contributions to our knowledge of Ceratodus; part i. The blood vessels. Macleay memorial volume, 34 p., pls. i-v. **92.1**.

3130. Valenti, G., *and* d'Abundo, G. Sulla vascolarizzazione cerebrale di alcuni mammiferi. Monitore zool. ital., i, 13. Atti soc. tosc. sc. nat. Pisa, xi, 36-44. **90.1**.

3131. Vialleton, L. Sur l'origine des germes vasculaires dans l'embryon du poulet. Anat. anz., vii, 624-627. **92.2**.

BONE.

3132. Corridi, G. Dei principale nuclei di ossificazione che possono rinvenirsi all' epoca della nascità; studio medico-legale sul fondamento di 285 osservazioni. L' anomalo. Napoli, iii, 143, 179, 231. **91.1**.

3133. Wolff, Jul. Ueber die theorie des knochenschwundes durch vermehrten druck und der knochenanbildung durch druckentlastung. Arch. f. klin. chirurgie, xlii, 302-324. **91.1**.

BRAIN.

3134. Cajal, S. Ramón y. Sur la fine structure du lobe optique des oiseaux et sur l'origine réelle des nerfs optiques. Interuat. monatsschr. f. anat. u. phys., viii, 337-366, taf. xxiii-xxiv. **91.2**.

3135. Edinger, L. Untersuchungen über die vergleichende anatomie des gehirns; ii. Das zwischenhirn. Abh. Senck. naturf. ges. Frankfurt a. M., xviii, 3-55, taf. i-v. **92.1**.

3136. Gehuchten, A. van. La structure des lobes optiques chez l'embryon de poulet. La cellule, viii, 1-43, pls. i-iii. **92.1**.

3137. Herrick, C. L. Additional notes on the teleost brain. Anat. anz., vii, 422-431. **92.1**.

3138. ——— Embryological notes of the brain of the snake. Journ. comp. neurology, ii, 160-176, pls. xv-xix. **92.3**.

3139. His, W. Zur allgemeinen morphologie des gehirns. His's Arch., 346-383. **92.1**.

3140. Holm, Harald. Die anatomie und pathologie des dorsalen vaguskerns; ein beitrag zur lehre der respirations und hustenreflex centra, ihrer entwickelung und degeneration. Arch. f. path. anat. u. phys. Berlin, cxxxi, 78-120, taf. ii-iv. **93.1**.

3141. Mingazzini, G. Sulle origini connessioni delle fibrae arciformes e del raphe nella porzione distale della oblongata dell' uomo. Intern. monatsschr. f. anat. u. phys., ix, 406-455, taf. xxii-xxiii. **92.1.**
3142. ——— Ulteriori ricerche intorno alle fibrae arciformes ed al raphe della oblongata nell' uomo. Intern. monatsschr. f. anat. u. phys., x, 105-130, taf. v-vi. **93.1.**
3143. Minot, C. S. Structural plan of the human brain. Pop. sc. monthly, xliii, 372-383. **93.130.**
3144. Symington, J. The cerebral commissures in the Marsupialia and Monotremata. Journ. anat. phys., xxvii, 69-84. **92.1.**
3145. Waters, B. H. Primitive segmentation of the vertebrate brain. Q. J. M. S., xxxiii, 457-475. **92.1.**

CELLS.

3146. Flemming, W. Zelle. Ergebnisse anat. entwick., i (1891), 43-82. **92.2.**

CELL DIVISION.

3147. Brauer, A. Zur kenntnis der herkunft des centrosomas. Biol. centralbl., xiii, 285-287. **93.1.**
3148. Bürger, O. Was sind die attraktionssphären? Anat. anz., vii, 222-231. **92.2.**
3149. Frenzel, J. Die mitteldarmdrüse des flusskrebses und die amitotische zelltheilung. Arch. f. mikr. anat., xli, 389-451, taf. xxv-xxvi. **93.1**
3150. Galeotti, G. Sulla presenza dei corpuscoli polari, della sfera di attrazione e del fuso acromatico nelle cellule di un tessuto umano patologico. Monitore zool. ital., iv, 18-19. **93.1.**
3151. Henneguy, F. Division des cellules embryonnaires dans le parablaste de la truite. C. R. soc. philom. Paris, 1891, Mar. 23, no. 15, 2 p. **91.2.**
3152. Lebrun, Hect. Les centrosomes dans l'oeuf de l'Ascaris megalocephala. Anat. anz., vii, 627-628. **92.1.**
3153. Nicolas, A. Contribution à l'étude de la division cellulaire. Arch. de phys., sér. 5, iv, 601, pl. iv. **92.2.**
3154. Prenant, A. L'origine du fuseau achromatique nucléaire dans les cellules séminales de la scolopendre. C. R. soc. biol. Paris, sér. 9, iv, 249-253. **92.3.**
3155. Watase, S. Homology of the centrosome. Journ. morph., viii, 433-443. **93.1.**

CELL THEORY.

3156. Altmann, R. Ein beitrag zur granulalehre. Verh. anat. ges. Wien, vi, 220-223. **92.1.**
3157. ——— Die granulalehre und ihre kritik. Arch. f. anat. u. phys., anat. abth., 55-66. **93.1.**
3158. Hansemann, D. Ueber centrosomen und attractionssphären in ruhenden zellen. Anat. anz., viii, 57-59. **92.1.**
3159. Mann, Gustav. The embryo sac of Myosurus minimus L.; a cell study. Trans. proc. bot. soc. Edinb., xix, 351-428, pls. iii-iv. **92.1.**
3160. Zimmermann, K. W. Studien über pigmentzellen; i. Ueber die anordnung des archiplasmas in den pigmentzellen der knochenfische. Arch. f. mikr. anat., xli, 367-389, taf. xxiii-xxiv. **93.1.**

CEREBELLUM.

3161. Berkley, H. J. The cerebellar cortex of the dog. Johns Hopkins hospital rep., iii, 195-214, pl. iii. **93.1.**
3162. Retzius, G. Die nervösen elemente der kleinhirnrinde. Biol. untersuch. Stockholm, iii, 17-24, taf. vii-ix. **92.1.**

COELOM.

3163. Ruge, Georg. Die grenzlinien der pleurasäcke und die lagerung des herzens bei primaten; insbesondere bei den anthropoiden; verkurzung des rumpfes. Morph. jahrb., xix, 149-249. **92.2.**
3164. Tanja, T. Ueber die grenzen der pleurahöhlen bei primaten und bei einigen anderen säugethieren. Morph. jahrb., xvii, 145-197. **91.1.**

CONJUGATION.

3165. Hertwig, R. Ueber befruchtung und conjugation. Verh. deutsch. zool. ges., 95-112. **92.1.**

CONNECTIVE TISSUE.

3166. Maurer, F. Die entwickelung des bindegewebes bei Siredon piscifórmis und die herkunft des bindegewebes im muskel. Morph. jahrb., xviii, 327-348, taf. xi. **92.1.**
3167. Retterer, Ed. Les découvertes récentes relatives au développement du tissu conjonctif. Journ. anat. et phys., xxviii, 211-224. **92.1.**

DECIDUA.

3168. Klein, Gustav. Entwicklung und rückbildung der decidua. Zeitschr f geburtsh. u. gynäk., xxii, 247-295, taf. vi. **91.1.**

3169. Spee, Graf. Ueber vorgänge bei bildung der fruchthöhle im uterus, speziel des meerschweinchens und des menschen. Mitth. ver. Schleswig-Holstein. ärzte, 1891, h. 12, stück 8. **91.2.**

EAR.

3170. Ayers, Howard. Vertebrate cephalogenesis; ii. A contribution to the morphology of the vertebrate ear, with a reconsideration of its functions. Journ. morph., vi, 1-360. pls. i-xii. **92.1.**

3171. ——— The macula neglecta again. Anat. anz , viii, 238-240. **93.1.**

3172. ——— Ueber das peripherische verhalten der gehörnerven und den wert der hörzellen des gehörorganes. Anat. anz., viii, 435-440. **93.2.**

3173. Baumgarten, H. Beiträge zur entwicklungsgeschichte der gehörknöchelchen. Arch. f. mikr. anat., xl, 512-530, taf. xxx. Berlin, 30 p. 8vo. (Inaug. diss.) **92.1.**

3174. Hertwig, O. Entwickelungsgeschichte des menschlichen ohres. Handb. d. ohrenheilk. Leipzig, i, 135-153. **92.3.**

3175. Norris, H. W. Studies on the development of the ear of Amblystoma; i. Development of the auditory vesicle. Journ. morph., vii, 23-34, pls. iii-iv. **92.1.**

3176. Reissner, E. De auris internae formatione. Dorpat, 53 p., 1 pl. 4to. (Inaug. diss.) **51.1.**

3177. Retzius, G. Die endigungsweise der gehörnerven. Biol. untersuch. Stockholm, iii, 29-36, taf. xi-xii. **92.3.**

3178. Schäffer, O. Ueber die vererbung fötaler ohrformen und die häufigkeit des vorkommens derselben bei erwachsenen. Sitzb. ges. morph. u. phys. München, viii, 42-51. **92.4.** See 3179.

EAR, EXTERNAL.

3179. Schäffer, O. Ueber die fötale ohrentwickelung, die häufigkeit fötaler ohrformen bei erwachsenen und die erblichkeitsverhältnisse derselben. Arch. f. anthrop., xxi, 77-132, 215-245. taf. ii-iii. **92.1.** See 3178.

ELASMOBRANCHS.

3180. Sedgwick, A. Notes on elasmobranch development. Q. J. M. S., xxxiii, 559-586. **92.1.**

3181. Wyman, Jeffries. Observations on the development of Raja batis. Mem. Am. acad. arts sc., ix. 37-44. **67.1.**

ELASTIC TISSUE.

3182. Heller, J. Beiträge zur histiogenese der elastischen fasern im netzknorpel und ligamentum nuchae. Monatsh. f. prakt. dermat. Hamburg, xiv, 217-237. **92.1.**

ELECTRIC ORGAN.

3183. Ewart, J. C. The electric organ of the skate. Phil. trans. roy. soc. Lond., clxxxiiiB, 389-420, pls. xxvi-xxx. **92.1.**

EPIDERMIS.

3184. Behn. Studien über die verhornung der menschlichen oberhaut. Arch. f mikr. anat., xxxix, 581-595, taf. xxvi. **92.1.**

3185. Römer, F. Zur frage nach dem ursprunge der schuppen der säugetiere. Anat. anz., viii, 526-532. **93.1.**

3186. Weber, Max. Bemerkungen über den ursprung der haare und über schuppen bei säugetieren. Anat. anz., viii, 413-423. **93.1.**

EPIPHYSIS.

3187. Klinckowström, A. de. Le premier développement de l'oeil pinéal, l'épiphyse et le nerf pariétal chez Iguana tuberculata. Anat. anz., viii, 289-299. **93.1.**

EVOLUTION.

3188. Baur, G. Abstammung der amnioten wirbeltiere. München. med. wochenschr., xxxiv, 441. **87.5**

3189. Osborn, H. F. The contemporary evolution of man. Am. nat., xxvi, 455-481. **92.1.**

3190. Ryder, J. A. Energy as a factor in organic evolution. Proc. Am. phil. soc., xxxi, 192-203. **93.1.**

3191. Virchow, R. Transformation and descent. Journ. path. bacteriol. Edinb. and Lond., i, 1-12. **92.1.**

EYE.

3192. Assheton, R. On the development of the optic nerve of vertebrates and the choroidal fissure of embryonic life. Q. J. M. S., xxxiv, 85-104. pl. xi-xii. **92.1.**

3192a. Chievitz, J. H. Die area und fovea centralis retinae beim menschlichen foetus. Internat. monatsschr. f. anat. u. phys., iv, 1-26, taf. viii. **87.1.**

3192b. ——— Untersuchungen über die entwickelung der area und fovea centralis retinae. Arch. f. anat. u. phys., anat. abth., 332-366, taf. xviii-xx. **90.1.**

3193. Ciaccio, G. V. Du mode de formation des vésicules primaires des yeux et pourquoi elles se transforment en secondaires; origine, formation et texture interne de l'humeur vitrée. Arch. ital. biol., xix, 232-240. **93.1.**

3194. Cirincione, G. Sui primi stadi dell' occhio umano. Giorn. assoc. Napol. med. e natur., ii, 403-439, 4 pls. **92.1.**

3195. Durand, G. Développement des muscles de l'iris chez l'embryon de poulet. C. R. soc. biol. Paris, sér. 9, v, 242-243. Abstract, Bibliogr. anat. Paris, i, 44. **93.1.**

3196. Henle, J. Zur entwickelungsgeschichte der krystallinse und zur teilung der zellkerne. Arch. f. mikr. anat., xx, 413-430, taf. xxvii. **82.1.**

3197. Merkel, Fr., *and* Orr, A. W. Das auge des neugeborenen an einem schematischen durchschnitt erläutert. Anat. hefte, abth. 1, h. i, 271-300. **92.1.**

3198. Meyer, H. Beitrag zur streitfrage über die entwickelung der linsenfasern. Müller's Arch., 202-204. **51.1.**

3199. Müller, H. Notiz über die netzhautgefässe bei einigen tieren. Würzburg. naturw. zeitschr., ii, 64. **61.1.**

3200. ——— Ueber die netzhautgefässe von embryonen. Würzburg. naturw. zeitschr., ii, 222-223. **61.2.**

3201. Virchow, H. Glaskörpergefässe und gefässhaltige linsenkapsel bei tierischen embryonen. Sitzb. phys.-med. ges. Würzburg, xx-xxii. **79.1.**

3202. Voll, A. Ueber die entwickelung der membrana vasculosa retinae. Festschr. f. A v. Kölliker, Leipzig, 87-93, 1 pl. **92.1.**

FACE.

3203. His, W. Die entwickelung der menschlichen und thierischer physiognomien. His's Arch., 384-424. **92.2.**

FOETAL ENVELOPES.

3204. Giacomini, E. Contributo alla migliore conoscenza degli anessi fetali nei rettili. Monitore zool. ital., iii, 126-128, 157-163, 185-196. Abstract: Arch. ital. biol., xviii (1893), 336-349. **92.1.**

GANGLIA.

3205. Lenhossék, M. v. Beobachtungen an den spinalganglien und dem rückenmark von Pristiurus-embryonen. Anat. anz., vii, 519-539. **92.2.**

3206. Morpurgo, B., *and* Tirelli, V. Sur le développement des ganglions intervertébraux du lapin. Arch. ital. biol., xviii, 413-434. **93.1.**

GANOIDS.

3207. Agassiz, Alex. The development of Lepidosteus. Proc. Am. acad. arts sc., xiv, 65-76, pl. i-iv. **78.2.**

GENERAL WORKS.

3208. Beard, J. On a supposed law of metazoan development. Anat. anz., viii, 22-29. **92.3.**

3209. Oppel, Albert. Vergleichung des entwicklungsgrades der organe zu verschiedenen entwicklungszeiten bei wirbeltieren. Jena, 181 p., 8vo. **91.2.**

3210. Roux, Wilhelm. Beiträge zur entwickelungsmechanik des embryo; vii. Ueber mosaikarbeit und neuere entwickelungshypothesen. Anat. hefte, abth. 1, h. ii, 277-333. **93.1.**

3211. Sabatier, A. Essai sur la vie et la mort. Paris, 282 p., 8vo. (Bibliothèque évolutioniste.) **92.1.**

GENITALIA, EXTERNAL.

3212. Klaatsch, H. Ueber embryonale anlagen des serotums und der labia majora bei arctopitheken. Morph. jahrb., xviii, 383. **92.1.**

3213. Retterer, É. Du développement du prépuce, de la couronne du gland et du col du pénis chez l'embryon humain. C. R. soc. biol. Paris, sér. 9, ii, 528-531. **90.3.**

3214. ——— Du développement du fourreau et de la partie libre de la verge des mammifères quadrupèdes. C. R. soc. biol. Paris, sér. 9, ii, 551-554. **90.4.**

GERM LAYERS.

3215. Davidoff, M. von. Die urmundtheorie. Anat. anz., viii, 397-404. **93.2.**
3216. Greenough, H. S. Sur les homologies des premiers stades suivant la segmentation chez les batraciens. Bull. soc. zool. France, xvii, 57-59. **92.1.**
3217. Heidenhain, Martin. Ueber das vorkommen von intercellularbrücken zwischen glatten muskelzellen und epithelzellen des äusseren keimblattes und deren theoretische bedeutung. Anat. anz., viii, 404-410. **93.2.**
3218. Henneguy, L. F. Sur la constitution de l'endoderme chez l'embryon des mammifères. C. R. soc. biol. Paris, sér. 9, iv, 277-279. **92.2.**
3219. Houssay, F. Sur la théorie des feuillets et le parablaste. C. R. acad. sc. Paris, cxiv, 1128-1130. **92.2.**
3220. Lwoff, B. Ueber die keimblätterbildung bei den wirbeltieren. Biol. centralbl., xiii, 40-50. **93 1.**
3221. Mitsukuri, K. On the mesoblast formation in the gecko. Anat. anz., viii, 431-434. **93.2.**
3222. Perényi, Josef Die entstehung des mesoderms. Math. u. naturw. berichte aus Ungarn, viii, 272-278, taf. i-ii. **91.1.**
3223. Rabl, C. Theorie des mesoderms. Morph. jahrb., xix, 65-144, taf. iv-vii. **92.2.**
3224. Remak, H. Ueber die genetische bedeutung des oberen keimblattes im eie der wirbelthiere. Verh. akad. wiss. Berlin, 25-26. Müller's Arch., 209-210. **51.1.**
3225. Samassa, Paul. Ueber einen primitivstreif in der area opaca. München, 24 p., 1 pl. 8vo. **90.1.**
3226. Smiechowski, A. Die bedeutung der megasphären in der keimscheibe des hühnchens. Anat. hefte, abth. 1, h. iii, 109-127. **92.1.**
3227. Stricht, O. van der. Sur l'existence d'ilôts cellulaires à la périphérie du blastoderme de poulet. Anat. anz., viii, 266-271. **93.1.**

GESTATION.

3228. Grieg, J. A. Ueber die tragzeit der Phocaena communis Less. Jen. zeitschr. f. naturw., xxv, 544-552. **91 1.**

GILLS.

3229. Virchow, Hans. Spritzlochkieme der selachier. Sitzb. ges. naturf. freunde, 31-33. **93.1.**

GROWTH.

3230. Schäffer, O. Gewichtsverluste der neugeborenen. Univ. frauenklin. München ber., Leipzig, 203-205. **92.3.**

HAIRS.

3231. Leydig, F. Besteht eine beziehung zwischen hautsinnesorganen und haaren? Biol. centralbl., xiii, 359-375. **93.1.**
3232. Maurer, F. Haut-sinnesorgane, feder- und haaranlagen, und deren gegenseitige beziehungen, ein beitrag zur phylogenie der säugetierhaare. Morph. jahrb., xviii, 717-804, taf. xxiv-xxvi. **92.2.**
3233. Möbius, K. Die behaarung des mammuths und der lebenden elephanten, vergleichend untersucht. Sitzb. preuss. akad. wiss. Berlin, 527-538, taf. iv. **92 1.**

HEAD.

3234. Goronowitsch, N. Die axiale und die laterale (A. Goette) kopfmetamerie der vogel-embryonen. Die rolle der sogenannten ganglienleisten im aufbaue der nervenstämme. Anat. anz., vii, 454-464. **92.1.**
3235. Kupffer, C. Mittheilungen zur entwicklungsgeschichte des kopfes bei Acipenser sturio. Sitzb. ges. morph. u. phys. München, 1891, 107-123. **92.2.**
3236. ——— Studien zur vergleichenden entwickelungsgeschichte; i. Die entwickelung des kopfes von Acipenser sturio an medianschnitten untersucht. München u. Leipzig, 95 p., 9 pls. 8vo. **93.1.**

HEART.

3237. Bruch, C. Ueber den schliessungsprocess des foramen ovale bei menschen und säugethieren. Abh. Senck. naturf. ges. Frankfurt a. M., iv, 46-62, taf. iii. **63 1.**
3238. Gibson, G. A. Some deductions from a study of the development of the heart. Edinb. med. journ., 1892, 429-433, 1 pl. **92.1.**
3239. Hoffmann, C. K. Zur entwickelungsgeschichte des herzens und der blutgefässe bei den selachiern; ein beitrag zur kenntnis des unteren keimblattes. Morph. jahrb., xix, 592-648, taf. xxii-xxv. **93.1.**

HEMISPHERES, CEREBRAL.

3239a. Antonini, A. La corteccia cerebrale nei mammiferi domestici. Monitore zool. ital., iii, 224-232, 243-248. **92.1.**

3240. Cajal, S. Ramón y. Sur la structure de l'écorce cérébrale de quelques mammifères La cellule, vii, 123-176, pl. i-iii. **91.1.**

3241. Retzius, G. Ueber den bau der oberflächenschicht der grosshirnrinde beim menschen und bei den säugethieren. Verh. biol. ver. Stockholm, iii, 90-102. **91.1.**

3242. ——— Die Cajal'schen zellen der grosshirnrinde beim menschen und bei säugethieren. Biol. untersuch. Stockholm, v, 1-8, taf. i-iv. **93.1.**

3243. Valenti, G. Contributo allo studio delle scissure cerebrali. Atti soc. tosc. sc. nat. Pisa, xi, 137-172, tav. viii. **91.3.**

3244. Vanhersecke, G. B. A. La morphologie des circonvolutions cérébrales; origine, développement, valeur morphologique et médicale des plis corticaux du cerveau. Lille, 143 p., 4to. (Thèse.) **91.1.**

HEREDITY.

3245. Barfurth, D. Halbbildung oder ganzbildung von halber grösse. Anat. anz., viii, 493-497. **93.1.**

3246. Boveri, Th. Ueber die entstehung des gegensatzes zwischen den geschlechtszellen und den somatischen zellen bei Ascaris megalocephala, nebst bemerkungen zur entwicklungsgeschichte der nematoden. Sitzb. ges. morph. u. phys. München, viii, 114-125. **92.3.**

3247. Emery, C. Gedanken zur descendenz- und vererbungstheorie. Biol. centralbl., xiii, 397-420. **93.1.**

3248. Harmer, Sidney F. On the occurrence of embryonic fission in cyclostomatous Polyzoa. Q. J. M. S., xxxiv, 199-241, pls. xxii-xxiv. **93.1.**

3249. Hurst, C. Herbert. Biological theories; i. The nature of heredity. Nat. science, i, 502-507. **92.1.**

3250. ——— Biological theories; ii. The evolution of heredity. Nat. science, i, 579-587. **92.2.**

3251. Miles, Manly. Heredity of acquired characters. Proc. Am. assoc. adv. sc., xli, 202-211. Am. nat., xxvi, 887-900. **92.1.**

3252. Nussbaum, M. Beiträge zur lehre von der fortpflanzung und vererbung. Arch. f. mikr. anat., xli, 119-145. **93.1.**

3253. Osborn, H. F. Heredity and the germ-cells. Am. nat., xxvi, 642-670. **92.3.**

3254. ——— The difficulties in the heredity theory. Am. nat., xxvi, 537-567. **92.2.**

3255. Weismann, A. Das keimplasma; eine theorie der vererbung. Jena, xviii, 628 p., 8vo. **92.1.** (For translation, see no. 3256.)

3256. ——— The germ-plasm; a theory of heredity. New York, 477 p., 8vo. **93.1.** (Translation of no. 3255.)

3257. Wilckens, M. Die vererbung erworbener eigenschaften vom standpunkte der landwirtschaftlichen tierzucht in bezug auf Weismann's theorie der vererbung. Biol. centralbl., xiii, 421-427. **93.1.**

HUMAN EMBRYO.

3258. Giacomini, C. Sur les anomalies de développement de l'embryon humain. Arch. ital. biol., xviii, 86-100, 1 pl. **92.2.**

3259. Hun, Henry. A case of tubal pregnancy. Am. journ. med. sc., lxxxviii, 98-103. **84.1.**

3260. Valenti, G. Intorno ad una anomalia di sviluppo dell' uovo umano. Arch. ital. biol., xviii, 160. Atti accad. chir. Perugia, iv. **92.1.**

HYPOPHYSIS.

3261. Schönemann, A. Hypophysis und thyreoidea. Virchow's Arch., cxxix, 310-336. **92.1.**

3262. Willey, A. On the development of the hypophysis in the ascidians. Zool. anz., xv, 332-334. **92.1.**

IMPREGNATION.

3263. Bischoff, Th. L. W. Bestätigung des von Dr. Newport bei den batrachiern und Dr. Barry bei den kaninchen behaupteten eindringens der spermatozoiden in das ei. Giessen, 10 p., 4to. **54.3.**

3264. Böhm, A. A. Die befruchtung des forelleneies. Sitzb. ges. morph. u. phys. München, vii (1892), 65-73. Münchener. med. woehenschr., xxxviii, 539-542. **91.1.**

3265. Born, G. Die reifung des amphibieneies und die befruchtung unreifer eier bei Triton taeniatus. Anat. anz., vii, 772-781, 803-811. **92.1.**

3266. Fick, Rudolf. Ueber die befruchtung des axolotleies. Anat. anz., vii, 818-821. **92.1.**

INTESTINE.

3267. Auerbach, L. Ueber einen plexus myentericus einen bisher unbekannten ganglionnervösen apparat im darmkanal der wirbelthiere. Breslau, 13 p., 8vo. **62.1.**

3268. ——— Fernere vorläufige mittheilung über den nervenapparat des darmes. Arch. f. path. anat., xxx, 457-460. **64.1.**

3269. Bizzozero, G. Sulle ghiandole tubulari del tubo gastro-enterico e sul rapporto del loro epitelio coll' epitelio di rivestimento della mucosa; nota i. Atti accad. sc. Torino, xxiv, 110-137, tav. iii. **88.2.**

3270. ——— Sulle ghiandole tubulari del tubo gastro-enterico, ecc.; nota ii. Ghiandole del intestino retto del Mus musculus. Atti accad. sc. Torino, xxvii. 14-34, 1 tav. **91.4.**

3271. ——— Sulle ghiandole tubulari del tubo gastro-enterico, ecc.; nota iii. Ghiandole del duodeno del topolino grigio. Atti accad. sc. Torino, xxvii, 320-346, 1 tav. **92.1.**

3272. ——— Sulle ghiandole tubulari del tubo gastro-enterico, ecc.; nota iv. Intestino delle lucertole. Atti accad. sc. Torino, xxvii, 891-903, 1 tav. **92.2.**

3273. ——— Sulle ghiandole tubulari del tubo gastro-enterico, ecc.; nota v. Intestino della larva del Petromyzon planeri. Atti accad. sc. Torino, xxvii, 988-1004, 1 tav. **92.3.**

3274. Bizzozero, G., *and* Vassale, G. Ueber die erzeugung und die physiologische regeneration der drüsenzellen bei den säugethieren. Virchow's Arch., cx, 155-214, taf. iii. **87.1.**

3275. Cloetta, M. Beiträge zur mikroskopischen anatomie des vogeldarmes. Arch. f. mikr. anat., xli, 88-119, taf. xi. **93.1.**

3276. Endres, H. Anatomisch-entwicklungsgeschichtliche studien über die formbildende bedeutung des blutgefässapparates unter besonderer berücksichtigung der damit verbundenen mechanischen einflüsse; i. Beiträge zur entwicklungsgeschichte und anatomie des darmes, des darmgekröses und der bauchspeicheldrüse. Arch. f. mikr. anat., xl, 435-483, taf. xxiv-xxvi. **92.1.**

3277. Heidenhain, R. Beiträge zur histologie und physiologie der dünndarmschleimhaut. Arch. f. phys. menschen u. thiere, xliii, suppl., 1-103, taf. i-iii. **88.1.**

3278. Kazzander, G. Sulle pliche della mucosa dell' intestino tenue dell' uomo. Monitore zool. ital., iii, 207-210. **92.1.**

3279. ——— Ueber die falten der dünndarmschleimhaut beim menschen. Anat. anz., vii, 768-771. **92.1.**

3280. Kieser, D. G. Der ursprung des darmkanals aus der vesicula umbilicalis, dargestellt im menschlichen embryo. Göttingen, 31 p., 2 pls. 4to. **10.1.**

3281. Mall, F. Reversal of the intestine. Johns Hopkins hospital rep., i, 93-110. **92.5.**

3282. Paneth, J. Ueber die secernirenden zellen des dünndarmepithels. Arch. f. mikr. anat., xxxi, 113-191, taf. viii-x. **88.1.**

3283. Stoss, A. Untersuchungen über die entwickelung der verdauungsorgane, vorgenommen an schafsembryonen. Erlangen, 32 p., 5 pls. 8vo. (Inaug. diss.) Deutsch. zeitschr. f. tiermed. u. vergl. path. Leipzig, xix (1893), 1-32. **92.1.**

JACOBSON'S ORGAN.

3284. Lenhossék, M. von. Die nervenursprunge und endigungen im Jacobson'schen organ des kaninchens. Anat. anz., vii, 628-635. **92.3.**

3285. Röse, C. Ueber das rudimentäre Jacobson'sche organ der crocodile und des menschen. Anat. anz., viii, 458-472. **93.2.**

LARYNX.

3286. Wilder, H. H. Studies in the phylogenesis of the larynx. Anat. anz., vii. 570-580. **92.2.**

LATERAL LINE.

3287. Ewart, J. C. The lateral sense organs of elasmobranchs; i. The sensory canals of Laemargus. Trans. roy. soc. Edinb., xxxvii, 59-84. **91.2.**

3288. Ewart, J. C., *and* Mitchell, J. C. The lateral sense organs of elasmobranchs, ii. The sensory canals of the common skate (Raia batis). Trans. roy. soc. Edinb., xxxvii, 87-105, pl. i-iii. **92.1.**

3289. Pollard, H. B. The lateral line system in siluroids. Zool. jahrb., abth. anat., v, 525-551, pls. xxxv-xxxvi. **92.1.**

LIMBS.

3290. Boyer, E. R. The mesoderm in teleosts; especially its share in the formation of the pectoral fin. Bull. mus. comp. zool., xxiii, 91-133, pls. i-viii. **92.1.**

3291. Holl, M. Ueber die entwickelung der stellung der gliedmassen des menschen. Sitzb. Wien. akad., c, abth. 3, 12-61. **91.3**.

3292. Kükenthal, W. Mittheilungen über den carpus des weisswals; die bildung des hamatums und das vorkommen von zwei und drei centralien. Morph. jahrb., xix, 56-64, taf. iii. **92.3**.

3293. Mollier, S. Zur entwickelung der selachier-extremitäten. Anat. anz., vii, 351-365. **92.1**.

LIVER.

3294. Felix, W. Zur leber- und pankreasentwickelung. Arch. f. anat. u. phys., anat. abth., 281-323, taf. xvi-xviii. **92.1**.

3295. Frobeen, Ferd. Zur entwickelung der vogelleber. Anat. hefte, abth. 1, h. iii, 365-372, taf. xxix. **92.1**.

3296. Jones, C. H. On the structure and development of the liver. Phil. trans. roy. soc. Lond., 109-137, pls. ix-xi. **49.1**.

3297. ——— Further inquiries as to the structure, development and function of the liver. Phil. trans. roy. soc. Lond., 1-28, pl. i. **53.1**.

3298. Jones, T. W. Microscopical examinations of the contents of the hepatic ducts, with conclusions founded thereon as to the physiological signification of the cells of hepatic parenchyma, and as to their anatomical relation to the radicles of the hepatic ducts. Phil. trans. roy. soc. Lond., 277-279. **48.1**.

3299. Kostanecki, K. v. Ueber kernteilung bei riesenzellen nach beobachtungen an der embryonalen säugetierleber. Anat. hefte, abth. 1, h. iii, 323-352, taf. xxv. **92.3**.

3300. Mall, F. Der einfluss des systems der vena portae auf die vertheilung des blutes. Arch. f. anat. u. phys., phys. abth., 409-453. **92.1**.

3301. Retzius, G. Weiteres über die gallenkapillaren und den drüsenbau der leber. Biol. untersuch., iv, 67-70, taf. xx-xxii. **92.5**.

LUNG.

3302. Narath, Albert. Vergleichende anatomie des bronchialbaumes. Verh. anat. ges. Wien, vi, 168-174. **92.1**.

MAMMAE.

3303. Schultze, O. Beitrag zur entwickelungsgeschichte der milchdrüsen. Verh. phys.-med. ges. Würzburg, xxvi, 171-182, taf. iii-iv. **93.1**.

MAMMALS.

3304. Fiserius, E. Beiträge zur entwickelungsgeschichte von Sciurus vulgaris. Verh. phys.-med. ges. Würzburg, xxvi, 1-20, taf. ii. Würzburg, 20 p. 1 pl. 8vo. **92.1**.

3305. Morgan, T. H. Development of mammals. Am. nat., xxv, 162-166. **91.1**.

3306. Paladino, G. Des premiers rapports entre l'embryon et l'utérus chez quelques mammifères. Arch. ital. biol., xiii, 59-70, pl. i. Giorn. assoc. nat. med. Napoli, i, no. 42. **90.1**.

3307. Retterer, E. Note sur la technique relative à l'extraction des oeufs de lapine. C. R. soc. biol. Paris, sér. 8, iii, 99-100. **87.2**.

3308. Römer, F. Ueber den bau und die entwickelung des panzers der gürteltiere. Jen. zeitschr. f. naturw., xxvii, 513-558, taf. xxiv-xxv. **92.1**.

3309. Selenka, E. Studien über entwickeluugsgeschichte der tiere; heft 5, zweite hälfte, 4. Affen Ostindiens; 5. Keimbildung des kalong (Pteropus edulis); 6. Dottersack und placenta des kalong von Dr. R. Göhre; p. 207-233, taf. xxxvi-xlii. **92.1**.

3310. Tafani, A. I primi momenti dello sviluppo dei mammiferi. Studi di morfologia normale e patologica eseguiti sulle uova dei topi. (Nota, p. 57.) Arch. anat. norm. path. Firenze, v, 3-59. 1st. stud. super. prat. e perfez. Firenze, sez. med. e chirurgia, 1-59. Abstract: Rend. accad. Linc., v, 119-125. **89.2**.

MARSIPOBRANCHS.

3311. Bujor, P. Contribution à l'étude de la métamorphose de l'Ammocoetes branchialis en Petromyzon planeri. Revue biol. nord France, iii, 301-315, 325-339, 365-390, 417-426, 474-486; iv, 41-60, pls. vi-ix. **91.1**.

3312. Hatta, S. On the formation of the germinal layers in Petromyzon. Journ. coll. sc. univ. Japan, v, 129-147, 2 pl. **92.1**.

3313. Julin, C. Recherches sur l'anatomie de l'Ammocoetes. Bull. sc. nord France, sér. 2, x. **87.4**.

MEDULLARY NERVE-CELLS.

3314. Dogiel, A. S. Zur frage über den bau der nervenzellen und über das verhältniss ihres axencylinder (nerven) fortsatzes zu den protoplasmafortsatzen (dendriten). Tomsk, 23 p., 1 pl. 8vo. **92.4.**

3315. Hodge, C. F. A microscopical study of changes due to functional activity in nerve cells. Journ. morph., vii, 95-168, pls. vii-viii. **92.1.**

MESENTERY.

3316. Dareste, C. Sur la formation du mésentère et de la gouttière intestinale dans l'embryon de la poule. C. R. acad. sc. Paris, cxii, 1514-1516. **91.1.**

3317. Klaatsch, H. Zur morphologie der mesenterial-bildungen am darmkanal der wirbeltiere; i. Amphibien und reptilien. ii. Säugethiere. Morph. jahrb., xviii, 385-450, 609-716, taf. xxii-xxiii. **92.2.**

METAMERISM.

3318. Cori, C. J. Ueber anomalien der segmentirung bei anneliden und deren bedeutung für die theorie der metamerie. Zeitschr. wiss. zool., liv, 569-578, taf. xxv. **92.1.**

3319. Hatschek, B. Die metamerie des Amphioxus und des Ammocoetes. Verh. anat. ges. Wien, vi, 136-161. **92.1.**

3320. ——— Zur metamerie der wirbeltiere. Anat. anz., viii, 89-91. **92.2.**

3321 Morgan, T. H. Spiral modification of metamerism. Journ. morph., vii, 245-251. **92.1.**

3322. Sewertzoff, A. N. Zur frage über die segmentierung des kopfmesoderms bei Pelobates fuscus. Bull. soc. nat. Moscou, 93-103. **92.1.**

MUSCLE.

3323. Calderara, G. Contributo alla conoscenza dello sviluppo della fibra muscolare striata. Arch. sc. med. Torino e Palermo, xvii, 89-97. Monitore zool. ital., iv, 42-43. **93.1.**

3324. Christomanos, A. A., *and* Strössner, E. Beitrag zur kenntnis der muskelspindeln. Sitzb. Wien. akad., c, abth. 3, 417-435, taf. i-iv. **91.1.**

3325. Kaestner, S. Ueber die allgemeine entwickelung der rumpf- und schwanzmuskulatur bei wirbeltieren; mit besonderer berücksichtigung der selachier. Arch. f. anat. u. phys., anat. abth., 153-222, taf. ix-xii. **92.1.**

3326. Kerschner, L. Ueber muskelspindeln. Verh. anat. ges. Wien, vi, 85-87. **92.1.**

3327. ——— Ueber die fortschritte in der erkenntnis der muskelspindeln. Anat. anz., viii, 449-458. **93.1.**

3328. Krösing, R. Ueber die rückbildung und entwickelung der quergestreiften muskelfasern. Virchow's Arch., cxxviii, 445-484, taf. xiii. **92.1.**

NERVES.

3329. Herrick, C. L. The development of the medullated nerve-fibres. Journ. comp. neurology, iii, 11-16. **93.1.**

3330. His, Wilhelm, Jun. Die entwickelung des herznervensystems bei wirbelthieren. Abh. math.-phys. cl. sächs. ges. wiss., xviii, 1-64, taf. i-iv. **91.1.**

3331. Howell, W. H., *and* Huber, G. C. A physiological, histological and clinical study of the degeneration and regeneration in peripheral nerve fibres after severance of their connections with the nerve centres. Journ. phys., xiii, 335-406, pls. xii-xvii. **92.1.**

NERVES, CEPHALIC.

3332. Chiarugi, G. Sullo sviluppo del nervo olfattivo nella Lacerta muralis. Monitore zool. ital., iii, 211-212. Abstract: Arch. ital. biol., xviii (1893), 363-364. **92.2.**

3333. David, J. On the histological structure of the medulla of Petromyzon. Journ. comp. neurology, ii, 92-94, 1 pl. **92.1.**

3334. Gehuchten, A. van. De l'origine du nerf oculomoteur commun. La cellule, viii, 421-431, taf. i. **92.3.**

3335. Golgi, Camillo. Intorno all' origine del quarto nervo cerebrale (patetico o trocleare) e di una questione di istofisiologia generale che a questo argomento si collega. Atti accad. d. linc., ser. 5, ii. Abstract: Monitore zool. ital., iv, 90-92. **93.1.**

3336. Held, Hans. Ueber eine directe akustische rindenbahn und den ursprung des vorderseitenstranges beim menschen. His's Arch., 257-264. **92.2.**

3337. Retzius, G. Die endigungsweise des riechnerven. Biol. untersuch. Stockholm, iii, 25-28, taf. x. **92.2.**

3338. Strong, Oliver S. The structure and homologies of the cranial nerves of the Amphibia as determined by their peripheral distribution and internal origin. Anat. anz., vii, 467-471. **92.1.**

3339. Wilder, H. H. Die nasengegend von Menopoma alleghaniense und Amphiuma tridactylum, nebst bemerkungen über die morphologie des ramus ophthalmicus profundus trigemini. Zool. jahrb., abth. anat., v, 155-176, taf. xii-xiii. **92.1.**

NERVOUS TISSUE.

3340. Herrick, C. L. Histology and physiology of the nervous elements. Journ. comp. neurology, ii, 137-149. **92.2.**

3341. Kölliker, A. von. Ueber die entwickelung der elemente des nervensystems, contra Beard und Dohrn. Verh. anat. ges. Wien, vi, 76-78. **92.2.**

3342. Lenhossék, M. von. Der feinere bau des nervensystems im lichte neuester forschungen. Fortschr. d. med., x, 571-584, 613-638, 665-687, 713-732, 801-813, 845-861, 889-899, 937-947, 981-989, taf. ii-v. Reprinted: Berlin, 139 p. 4 pls. 8vo. **92.4.**

3343. Masius, J. Recherches histologiques sur le système nerveux central. Arch. de biol., xii, 151-167, pl. vi. **92.1.**

3344. Mazzoni, V. Ricerche embryologiche sull' origine e formazione delle fibre nervose, ecc. Bull. sc. med. Bologna, ser. 7, ii, 389-390. **91.1.**

3345. Retzius, G. Kleinere mittheilungen von dem gebiete der nervenhistologie; i. Ueber die Golgi'schen zellen und die kletterfasern Ramón y Cajal's in der kleinhirnrinde; ii. Zur kenntniss der ganglienzellen der spinalganglien; iii. Zur kenntniss der nervenendigungen in der riechschleimhaut; iv. Zur kenntniss der drüsennerven; v. Zur kenntniss der nervenendigungen in den zähnen. Biol. untersuch. Stockholm, iv, 57-66, taf. xvii-xix. **92.4.**

3346. Schäffer, E. A. The nerve cell considered as the basis of neurology. Brain, London, 134-169. **93.1.**

NEUROGLIA.

3347. Retzius, G. Studien über ependym und neuroglia. Biol. untersuch. Stockholm, v, 9-26, taf. v-xiii. **93.2.**

NEUROMERES.

3348. Froriep, Aug. Zur frage der sogenannten neuromerie. Verh. anat. ges. Wien, vi, 162-167. **92.3.**

NEURON.

3349. Locy, W. A. The formation of the medullary groove in the elasmobranchs. Journ. morph., viii, 367-378, pl. xix. **93.1.**

NOSE.

3350. Hochstetter, Fr. Ueber die bildung der primitiven choanen beim menschen. Verh. anat. ges. Wien, vi, 181-183. **92.3.**

3351. Keibel, F. Zur entwickelungsgeschichte und vergleichenden anatomie der nase und des oberen mundrandes (oberlippe) bei vertebraten. Anat. anz., viii, 473-487. **93.1.**

3352. Preobaschensky, S. Beiträge zur lehre über die entwickelung des geruchsorganes des huhnes. Mitth. embryol. inst. univ. Wien, 1-19, taf. i. **92.1.**

NOTOCHORD.

3353. Retzius, G. Einige beiträge zur histologie und histochemie der chorda dorsalis. Arch. f. anat. u. phys., anat. abth., 89-110, taf. iv-v. **81.4.**

3354. Schmidt, V. Das schwanzende der chorda dorsalis bei den wirbelthieren. Anat. hefte, abth. 1, h. ii, 335-388, taf. xvi-xviii. **93.1.**

NUCLEI.

3355. Flemming, W. Ueber unsichtbarkeit lebendiger kernstrukturen. Anat. anz., vii, 758-764. **92.3.**

3356. Macallum, A. B. On the demonstration of the presence of iron in chromatin by micro-chemical methods. Proc. roy. soc. Lond., l, 277-286. **91.2.**

OLFACTORY LOBES.

3357. Gehuchten, A. van, *and* Martin, J. Le bulbe olfactif chez quelques mammifères. La cellule, vii, 203-237, taf. i-ii. **91.1.**

3358. Golgi, Camillo. Sulla fina struttura dei bulbi olfattorii. Reggio-Emilia, 23 p. 1 pl. 8vo. **75.1.**

OVARY.

3359. Calderwood, W. L. Contribution to the knowledge of the ovary and intra-ovarian egg in teleosteans. Notes on Centrina salvini. Journ. mar. biol. assoc. United Kingdom, ii, 298-313, pls. xi-xii. **92.1.**

3360. Schottlaender, J. Ueber den Graaf'schen follikel, seine entstehung beim menschen und seine schicksale bei mensch und säugethieren. Arch. f. mikr. anat., xli, 219-294, taf. xv-xvi. **93.1.**

3361. Strahl, H. Die rückbildung reifer eierstockseier am ovarium von Lacerta agilis. Verh. anat. ges. Wien, vi, 190-195. **92.2.**

3362. Wasielewski, von. Die keimzone in den genitalschläuchen von Ascaris megalocephala. Arch. f. mikr. anat., xli, 324-337, taf. xix. **93 1.**

OVULATION.

3363. Bischoff, Th. L. W. Beweis der von der begattung unabhängigen periodischen reifung und loslösung der eier der säugethiere und des menschen als der ersten bedingung ihrer fortpflanzung. Giessen, 54 p. 4to. **44.1.**

3364. Hennig, C. Ueber menstruation und ovulation. Sitzb. naturf. ges. Leipzig, xviii, 81-84. **92.1.**

3365. Veit, J. Die frage der inneren überwanderung des eies. Zeitschr. f. geburth. u. gynäk., xxiv, 327-356. **92.1.**

OVUM.

3366 Arnold, A. F. Beiträge zur kenntnis des reptilien-ovulums. Erlangen, 39 p. 8vo. (Inaug. diss.) **92.1.**

3367. Bernhardt, A. Symbolae ad ovi mammalium historiam ante praegnationem. Vratislaviae, 46 p. 1 pl. 4to. **34.1.**

3368. Henneguy, L. F. Essai de classification des oeufs des animaux au point de vue embryogénique. Bull. soc. philom. Paris, sér. 8, iv, 37-44. **92.1.**

3369. ——— Le corps vitellin de Balbiani dans l'oeuf des vertébrés. Journ. anat. et phys., xxix, 1-39, pl. i. **93.1.**

3370. Herbst, Curt. Ueber die künstliche hervorrufung von dottermembranen an unbefruchteten seeigeleiern nebst einigen bemerkungen über die dotterhautbildung überhaupt. Biol. centralbl., xiii, 14-22. **93.1.**

3371. Rückert, J. Ueber die verdoppelung der chromosomen im keimbläschen des selachiereies. Anat. anz., viii, 44-52. **92.4.**

3372. Ryder, J. A. The mechanical genesis of the form of the fowl's egg. Proc. Am. phil. soc., xxxi, 203-209. **93.2.**

PANCREAS.

3373. Goeppert, E. Die entwickelung des pankreas der teleostier. Morph. jahrb., xx, 90-111. **93.1.**

3374. Hamburger, Ove. Zur entwickelung der bauchspeicheldrüse des menschen. Anat. anz., vii, 707-711. **92.1.**

3375. Laguesse, E. Note sur l'histogénie du pancréas: la cellule centroacineuse. C. R. soc. biol. Paris, sér. 9, v, 622-624. **93.2.**

3376. ——— Sur les bourgeons pancréatiques accessoires et l'origine du canal pancréatique chez les poissons. C. R. soc. biol. Paris, sér. 9, v, 402-404. **93.1.**

3377. Stöhr, Philipp. Die entwickelung von leber und pankreas der forelle. Anat. anz., viii, 205-208. **93.1.**

PARTHENOGENESIS.

3378. Taschenberg, O. Historische entwickelung der lehre von der parthenogenesis. Abh. naturf. ges. Halle, xvii, 365-454. Festschr. naturf. ges. f. R. Leuckart, 109-197. **92.1.**

3379. Wasmann, E. Parthenogenesis bei ameisen durch künstliche temperaturverhältnisse. Biol. centralbl., xi, 21-23. **91.1.**

PIGMENT CELLS.

3380. Ehrmann. Zur kenntnis von der entwicklung und wanderung des pigments bei den amphibien. Arch. f. dermatol. u. syph. Wien, xxiv, 195-222, 2 pls. **92.1.**

PINEAL GLAND.

3381. Béraneck, Ed. Sur le nerf pariétal et la morphologie du troisième oeil des vertébrés. Anat. anz., vii, 674-689. **92.1.**

3382. Duval, M. Le troisième oeil des vertébrés, leçons faites à l'École d'anthropologie, recueillies par P. G. Mahoudeau. Journ. de micrographie, Paris, xii, 250, 273, 308, 336, 368, 401, 429, 459, 500, 523; xiii (1889), 16, 42, 76. **88.3.**

PLACENTA.

3383. Bumm, E. Zur kenntniss der uteroplacentargefässe. Arch. f. gynäk., xxxvii, 1-15, taf. i-iii. **90.1.**

3384. ——— Ueber die entwickelung der menschlichen placenta. Sitzb. phys.-med. ges. Würzburg, 78-85. München. med. wochenschr., xxxviii, 563-564. **91.1.**

3385. ——— Ueber die entwickelung des mütterlichen blutkreislaufes in der menschlichen placenta. Arch. f. gynäk., xliii, 181-195, taf. v-vii. **93.1.**

3386. Duval, M. Le placenta des rongeurs. Journ. anat. et phys., xxvii, 515-612, pls. xxiii-xxv. **91.2.**

3387. ——— Le placenta des rongeurs. Le placenta du cochon d'Inde. Journ. anat. et phys., xxviii, 333-453, pls. xvi-xvii. **92.1.**

3388. ——— Le placenta des rongeurs et l'inversion des feuillets blastodermiques. C. R. soc. biol. Paris, sér. 9, iv, 917-919. **92.2.**

3389. — ——— Le placenta des rongeurs. Paris, 640 p. 4to. Atlas, 22 pls. **92 3.**

3390. Favre, A. Ueber den weissen infarct der menschlichen placenta. Virchow's Arch., cxx, 460-476. **90.1.**

3391. Fleischmann, A. Der einheitliche plan der placentarbildung bei nagetieren. Sitzb. preuss. akad. wiss. Berlin, 445-457, taf. iii. **92.1.**

3392. Göhre, R. Dottersack und placenta des kalong. Selenka's Stud. ü. entwick. d. tiere. heft 5, hälfte 2. **92.1.**

3393. Gottschalk, M. Placenta duplex. Zeitschr. f. geburth. u. gynäk., xxiv, 148-149. **92 1.**

3394. Gulland, G. L., *and* Hart, D. B. On the structure of the human placenta, with special reference to the origin of the decidua reflexa. Lab. rep. coll. physicians Edinb., iv, 17-35, pls. iii-v. **92.1.**

3395. König, K. P. Ueber uteroplacentargefässe, ihr makroskopisches und mikroskopisches verhalten. Würzburg, 32 p. 8vo. (Inaug. diss.) **91.1.**

POLAR GLOBULES.

3396. Häcker, V. Die richtungskörperbildung bei Cyclops und Canthocamptus. Ber. naturf. ges. Freiburg i. B., vi, 30-32. **91.1.**

3397. Henking, H. Ueber die bildung von richtungskörpern in den eiern der insekten und deren schicksal. Nachr. ges. wiss. Göttingen, 444-449. **88.1.**

PREGNANCY.

3398. Waldeyer, W. Beiträge zur kenntniss der lage der weiblichen beckenorgane nebst beschreibung eines frontalen gefrierschnittes des uterus gravidus in situ. Bonn, 29 p., 5 pls. fol. **92.1.**

PRIMATES.

3399. Hart, D. Berry. The anatomy of advanced pregnancy in Macacus rhesus studied by frozen sections, by casts and microscopically. Journ. anat. phys., xxvii, 361-376, pl. xxii. **93.1.**

3400. Kollmann, J. Affen-embryonen aus Sumatra und Ceylon. Anat. anz., vii, 335-340. **92.1.**

3401. ——— Beiträge zur embryologie der affen. Arch. f. anat. u. phys., anat. abth., 137-152, taf. viii. **92.2.**

PROTOPLASM.

3402. Kromayer, E. Die protoplasmafaserung der epithelzelle. Arch. f. mikr. anat., xxxix, 141-150, taf. vii. **92.1.**

REPTILES.

3403. Giacomini, E. Sullo sviluppo del Seps chalcides. Atti accad. fisiocrit. Siena, ser. 4, iv, 59-62. **92.2.**

3404. Haycraft, J. B. The development of the carapace of the Chelonia. Trans. roy. soc. Edinb., xxxvi, 335-342, 1 pl. **91.1.**

3405. Mehnert, E. Gastrulation und keimblätter-bildung der Emys lutaria taurica. Morph. arb., i, 365-495, taf. xvii-xxi. **92.1.**

3406. Mitsukuri, K. Contributions to the embryology of Reptilia; iii. Further studies on the formation of germinal layers in Chelonia. Journ. coll. sc., Tokyo, v, 35-52, pls. ii-iv. **92.1.**

3407. ——— Preliminary note on the process of gastrulation in Chelonia. Anat. anz., viii, 487-493. **93.1.**

3408. Rathke, H. Untersuchungen über die entwickelung und den körperbau der krokodile. Braunschweig, 275 p. pls. i-v, vii-xi. 4to. **66.1.**

3409. Todaro, F. Sopra lo sviluppo della Seps chalcides. Ricerche anat. univ. Roma, iii. Monitore zool. ital., iv, 87-90. **93.1.**

3410. Voeltzkow, A. Ueber eiablage und embryonal-entwicklung der krokodile. Sitzb. preuss. akad. wiss. Berlin, 115-120. **91.1.**

3411. Will, Ludwig. Beiträge zur entwicklungsgeschichte der reptilien; i. Die anlage der keimblätter beim gecko (Platydactylus facetanus Schreib.). Zool. jahrb., abth. anat., vi, 1-160, taf. i-xi. **92.2.**

RETINA.

3412. Dogiel, A. S. Ueber die nervösen elemente in der retina des menschen. Arch. f. mikr. anat., xl, 29-38, taf ii. **92.2.**

3413. Mall, F. Histogenesis of the retina in Amblystoma and Necturus. Journ. morph., viii, 415-432. **93.1.**

3414. Schaper, A. Zur histologie der menschlichen retina, spec. der macula lutea und der Henle'schen faserschicht. Arch. f. mikr. anat., xli, 147-167, taf. xii. **93.1.**

RODENTS.

3415. Cristiani, H. L'inversion des feuillets blastodermiques chez le rat albinos. Arch. phys. norm. path., sér. 5, iv, 1-12, pl. i-ii. **92 1.**

SEGMENTAL ORGANS.

3416. Vejdovsky, F. Zur entwicklungsgeschichte des nephridial-apparates von Megascolides australis. Arch. f. mikr. anat., xl, 552-562, taf. xxxii. **92.1.**

SEGMENTATION.

3417. Born, G. Ueber die furchung des eies bei doppelbildungen. Breslau. ärztl. zeitschr., no. 15, 1-16. **87.1.**

3418 Dehner, H. Ueber die sogenannte parthenogenetische furchung des froscheies. Würzburg, 18 p., 1 pl. 8vo. (Inaug. diss.) **92.1.**

3419. Driesch, Hans. Entwicklungsmechanische studien; iii. Die verminderung des furchungsmaterials und ihre folgen (weiteres über theilbildungen). iv. Experimentelle veränderungen des typus der furchung und ihre folgen (wirkungen von wärmezufuhr und von druck). v. Von der furchung doppeltbefruchteter eier. vi. Ueber einige allgemeine fragen der theoretischen morphologie. Zeitschr. wiss. zool., lv, 1-62, taf. i-iii. **92.1.**

3420. Häcker, V. Das keimbläschen, seine elemente und lageveränderungen; i. Ueber die biologische bedeutung des keimbläschenstadiums und über die bildung der vierergruppen. Arch. f. mikr. anat., xli, 452-492, taf. xxvii-xxviii. **93.1.**

3421. Jordan, E. O., *and* Eycleshymer, A. C. The cleavage of the amphibian ovum. Anat. anz., vii, 622-624. **92.1.**

3422. Loeb, Jacques. Investigations in physiological morphology; iii. Experiments on cleavage. Journ. morph., vii, 253-262. **92.1.**

3423. Roux, W. Ueber das entwickelungsmechanische vermögen jeder der beiden ersten furchungszellen des eies. Verh. anat. ges. Wien, vi, 21-62. **92.1.**

3424. Schultze, O. Ueber die karyokinese in den ersten zellen (furchungskugeln) des Axolotl. Ueber lageveränderungen des kernes in den zellen. Sitzb. phys.-med. ges. Würzburg, 2-5. **87.3.**

3425. Tourneux, F. Sur les modifications que subit l'oeuf de la lapine pendant sa migration dans l'oviducte et sur la durée de cette migration. C. R soc. biol. Paris, sér. 9, i, 311-314. **89.4.**

3426. Vay, Franz. Zur segmentation von Tropidonotus natrix. Anat. hefte, abth. 1, h. ii, 27-58. **92.1.**

SEX.

3427. Short, J. L. The determination of sex of the foetus. N. Y. med. journ., liv, 576. **91.1.**

3428. Watase, S. On the phenomena of sex differentiation. Journ. morph., vi, 481-493. **92.1.**

3429. Wilson, A. A theory of sex. Lancet, ii, 713-714. **91.1.**

SEXUALITY.

3430. Auerbach, L. Ueber einen sexuellen gegensatz in der chromatophilie der keimsubstanzen, nebst bemerkungen zum bau der eier und ovarien niederer wirbeltiere. Sitzb. preuss. akad. wiss. Berlin, 713-750. **91.3.**

SKELETON.

3431. Fehling, H. Die form des beckens beim foetus und neugeborenen. Arch. f. gynäk., x, 1-80, taf. i-ii. **76.1.**
3432. Julien, A. Loi de l'apparition du premier point épiphysaire des os longs. C. R. acad. sc. Paris, cxiv, 926-929. **92.1.**
3433. Kükenthal, W. Zur entwickelung des handskelettes des krokodils. Morph. jahrb., xix, 42-55, taf. ii. **92.2.**
3434. Petersen, H. Untersuchungen zur entwicklung des menschlichen beckens. Arch. f. anat. u. phys., anat. abth., 67-96, taf. vii-viii. **93.1.**
3435. Wiedersheim, R. Die phylogenie der beutelknochen; eine entwickelungsgeschichtlich-vergleichend anatomische studie. Zeitschr. wiss. zool., liii, suppl., 43-66, taf. vi-vii. **92.1.**

SKULL.

3436. Bianchi, S. Sopra alcune varietà del cranio osservate in feti umani ed in altri mammiferi. Monitore zool. ital., iv, 11-17. **93.1.**
3437. Cope, E. D. On the homologies of the posterior cranial arches in the Reptilia. Trans. Am. phil. soc., xvii, 11-26, pls. i-v. **92.1.**
3438. Gaupp, E. Grundzüge der bildung und umbildung des primordialcraniums von Rana fusca. Verh. anat. ges. Wien, vi, 183-190. **92.1.**
3439. ——— Beiträge zur morphologie des schädels; i. Primordial-cranium und kieferbogen von Rana fusca. Morph. arb., ii, 275-481, taf. xiii-xvi. **92.2.**
3440. Platt, J. B. Ectodermic origin of the cartilages of the head. Anat. anz., viii, 506-509. **93.1.**
3441. Schäffer, Oskar. Untersuchungen über die normale entwickelung der dimensions-verhältnisse des fötalen menschenschädels mit besonderer berücksichtigung des schädelgrundes und seiner gruben. München und Leipzig, 51 p. 5 pls. 4to. **92.2.**
3442. Zuckerkandl. Die entwickelung des siebbeines. Verh. anat. ges. Wien. vi, 261-264. **92.2.**

SPERMATOGENESIS.

3443. Field, G. L. Echinoderm spermatogenesis. Anat. anz., viii, 487-493. **93.1.**
3444. Henking, H. Ueber reductionstheilung der chromosomen in den samenzellen von insekten. Intern. monatsschr. f. anat. u. phys., vii, 243-248. **90.1.**
3445. Herrmann, G. Sur la structure et le développement des spermatozoïdes chez les décapodes. Bull. sc. France et Belg., xxii, 1-59, pls. i-iv. **90.1.**
3446. Nicolas, A. Les spermatogonies chez la salamandre d'hiver (noyaux polymorphes, sphère attractive, division directe). C. R. soc. biol. Paris, sér. 9, iv, 590-595. **92.1.**
3447. Prenant, A. Sur la signification de la cellule accessoire du testicule et sur la comparaison morphologique des éléments du testicule et de l'ovaire. Journ. anat. et phys., xxviii, 292-355. **92.1.**
3448. Rath, O. von. Zur kenntnis der spermatogenese von Gryllotalpa vulgaris Latr. Arch. f. mikr. anat., xl, 102-132, taf. v. **92.1.**
3449. Sabatier, A. De la spermatogenèse chez les crustacés décapodes. Trav. inst. zool. Montpellier, n. s., mém. 3· 393 p., 10 pls. **93.1.**

SPERMATOZOA.

3450. Ballowitz, E. Zu der mitteilung des Herrn Prof. L. Auerbach in Breslau über "Merkwürdige vorgänge am sperma von Dytiscus marginalis." Anat. anz., viii, 505-506. **93.1.**
3451. Bardeleben, K. von. Ueber spermatogenese bei säugetieren, besonders beim menschen. Verh. anat. ges. Wien, vi, 202-208. **92.1.**
3452. Benda, C. Ueber die histiogenese des sauropsidenspermatozoons. Verh. anat. ges. Wien, vi, 195-199. **92.1.**
3453. Piersol, G. A. Duration of motion of human spermatozoa. Anat. anz., viii. 299-301. **93.1.**

SPLEEN.

3454. Gaule, Alice L. Biological changes in the spleen in the frog. Journ. morph., viii, 393-414. **93.1.**
3455. Gray, Henry. On the development of the ductless glands in the chick. Phil. trans. roy. soc. Lond., 295-309, pls. xxi-xxii. **52 1.**
3456. Kupffer, C. v. Ueber die entwicklung von milz und pankreas. München. med. abh., vii, h. 4. Reprint, 17 p. **92.1.**

SPINAL CORD.

3457. Tourneux, F. Sur la structure et sur le développement du fil terminal de la moelle chez l'homme. C. R. soc. biol. Paris, sér. 9, iv, 340-343. **92.1.**

STOMACH.

3458. Fleischmann, A. Bemerkungen über den magen der Rodentia. Morph. jahrb., xvii, 408-416. **91.3.**
3459. Toepfer, K. Die morphologie des magens der Rodentia. Morph. jahrb., xvii, 380-407, taf. xxiv. **91.1.**

SUPRA-RENALS.

3460 Fusari, R. Contribution à l'étude du développement des capsules surrénales et du sympathique chez le poulet et chez les mammifères. Arch. ital. biol., xviii, 161-182. Monitore zool. ital., iv, 7-10. **92.1.**
3461. Inaba, M. Notes on the development of the suprarenal bodies in the mouse. Journ. coll. sc. univ. Japan, iv, 215-237, pls. xxx-xxxi. **91.1.**
3462. Pilliet, A. Débris de capsule surrénale dans les organes dérivés du corps de Wolff. Progrès méd. Paris, xiii, 4-6. **91.1.**

SYMPATHETIC.

3463. Gehuchten, A. van. Les cellules nerveuses du sympathique chez quelques mammifères et chez l'homme. La cellule, viii, 81-95, 1 pl. **92.2.**
3464. His, W., Jr. Ueber die entwickelung des sympathicus bei wirbeltieren mit besonderer berücksichtigung der herzganglien. Verh. anat. ges. Wien, vi, 69-75. **92.1.**
3465. Sala, L. Sulla fine anatomia dei gangli del simpatico. Monitore zool. ital., iii, 148-157, 172-184. Abstract: Arch. ital. biol., xviii, 439-458. **92.1.**

TEETH.

3466. Annell, G. Beiträge zur kenntnis der zahnbildenden gewebe des menschen und der säugethiere. Biol. untersuch. Stockholm, ii, 33-70, taf. iii-v. **82.1.**
3467. Ballowitz, E. Das schmelzorgan der edentaten, seine ausbildung im embryo und die persistenz seines keimrandes bei den erwachsenen thier. Arch. f. mikr. anat., xl, 133-156, taf. vi-vii. **92.1.**
3468. Freund, P. Beiträge zur entwickelungsgeschichte der zahnanlagen bei nagetieren. Arch. f. mikr. anat., xxxix, 525-555, taf. xxii-xxiii. **92.1.**
3469. Kükenthal, W. Ueber den ursprung und die entwickelung der säugetierzähne. Jen. zeitschr. f. naturw., xxvi, 469-489. **92.1.**
3470. Leche, W. Studien über die entwickelung des zahnsystems bei den säugetieren. Morph. jahrb., xix, 502-547. **92.1.**
3471. Mummery, J. H. Some points in the structure and development of dentine. Phil. trans. roy. soc. Lond., clxxxii, 527-545, pls. xxxvi-xxxix. **91.1.**
3472. Oldfield, T. Notes on W. Kükenthal's discoveries on mammalian dentition. Ann. mag. nat. hist., ser. 6, ix, 308-313. **92.1.**
3473. Osborn, H. F. The history and homologies of the human molar cusps. Anat. anz., vii, 740-747. **92.4.**
3474. ——— Recent researches upon the succession of the teeth in mammals. Am. nat., xxvii, 493-508. **93.1.**
3475. Robertson, W. G. A. On the relation of nerves to odontoblasts and on the growth of dentine. Trans. roy. soc. Edinb., xxxvi, 321-334, 1 pl. **92.1.**
3476. Röse, C. Beiträge zur zahnentwickelung der edentaten. Anat. anz., vii, 495-512. **92.1.**
3477. ——— Ueber rudimentäre zahnanlagen der gattung Manis. Anat. anz., vii, 618-622. **92.2.**
3478. ——— Ueber die zahnentwickelung der beuteltiere. Anat. anz., vii, 639-650, 693-707. **92.3.**
3479. ——— Ueber die zahnleiste und die eischwiele der sauropsiden. Anat. anz., vii, 748-758. **92.4.**

3480. Röse, C. Ueber die zahnentwickelung der krokodile. Verh. anat. ges. Wien, vi, 225-226. **92.5.**
3481. ——— Ueber zahnbau und zahnwechsel der dipnoer. Anat. anz., vii, 821-839. **92 6.**
3482. ——— Zur phylogenie des säugetiergebisses. Biol. centralbl., xii, 624-638. **92.7.**
3483. ——— Ueber die verwachsung von retinirten zahnen mit dem kieferknochen. Anat. anz., viii, 82-89. **92 8.**
3484. ——— Ueber die zahnentwickelung der reptilien. Deutsch. monatsschr. f. zahnheilk. Leipzig, x, 127-149. **92.9.**
3485. ——— Ueber die nichtexistenz der sogenannten Weilschen basalschicht der odontoblasten. Anat. anz., viii, 272-285. **93.1.**
3486. Talbot, E. S. A study of the degeneracy of the jaws of the human race. Philadelphia, 63 p. 8vo. **92.1.**
3487. Woodward, M. T. On the milk dentition of Procavia (Hyrax) capensis and of the rabbit (Lepus cuniculus) with remarks on the relation of the milk and permanent dentitions of the Mammalia. Proc. zool. soc. Lond., 38-49, pl. ii. **92.1.**

TELEOSTS.

3488. Fusari, R. Sur les premières phases de développement des téléostéens. Arch. ital. biol., xviii, 204-239. **92.2.**
3489. McIntosh. Notes from the St. Andrews marine laboratory; i. On the eggs and young stages of the sand eels. Ann. mag. nat. hist., ser. 6, x, 97-108, pl. viii. **92.1.**
3490. Olt, Ad. Lebensweise und entwickelung des bitterlings. Zeitschr. wiss. zool., lv, 513-575, taf. xxiii. **93.1.**

TERATOLOGY.

3491. Dareste, C. Recherche sur la production artificielle des monstruosités ou essais de tératogénie expérimentale. Paris, v, 364 p. 16 pls. 8vo. **77.2.**
3492. Giacomini, C. Sur les anomalies de développement de l'embryon humain; produit abortif avec forme nodulaire. Arch. ital. biol., xviii, 400-412, pl. vi. **93.1.**
3493. ——— Su alcune anomalie di sviluppo dell' embrione umano; iii. Gravidanza tubarica. Atti accad. sc. Torino, xxvii, 64-85, taf. iv. **91.1.**
3494. ——— Su alcune anomalie di sviluppo dell' embrione umano; iv. Ovalo completo con embrione atrofico. Atti accad. sc. Torino, xxvii, 802-816, taf. v. **91.2.**
3495. ——— Su alcune anomalie di sviluppo dell' embrione umano; v. Prodotto abortivo con forma nodulare. Atti accad. sc. Torino, xxvii, 1004-1016, taf. vi. **91.3.**
3496. ——— Su alcune anomalie di sviluppo dell' embrione umano; vi. Mancanza dell' embrione; Cisti dell' amnios; Formazioni epiteliari nel chorion e nello stroma delle villosità. Atti accad. sc. Torino, xxviii, 24-39, taf. vii. **92.4.**
3497. His, Wilhelm. Offene fragen der pathologischen embryologie. Intern. beitr. wiss. med., festschr. R. Virchow, i, taf. viii. **91.3.**
3498. Lachi, P. Di un novo umano mostruoso. Monitore zool. ital., iii, 197-203, 218-223, taf. iv. **92 1.**
3499. Spencer, W. B. Formation of a double embryo in the hen's egg. Proc. roy. soc. Victoria, ii, 113-115. **90 1.**
3500. Windle, B. C. On the myology of the anencephalous foetus. Journ. anat. phys., xxvii, 348-353. **93 1.**

TESTIS.

3501. Germano, E. Ricerche istologiche sul testicolo dalla nascità alla maturità. Intern. monatsschr. f. anat u. phys., ix, 241-255, taf. xiv. **92.1.**
3502. Schäffer, J. Ueber drüsen im epithel der vasa efferentia testis beim menschen. Anat. anz., vii, 711-717. **92.1.**

TEXT-BOOKS.

3503. Chievitz, J. H. Fosterets udvikling fremstillet for medicinske studerende. Kjobenhavn, 193 p. 8vo. **91.1.**
3504. Hertwig, O. Text-book of the embryology of man and mammals; translated by E. L. Mark. London and New York, xvi, 670 p. 8vo. **92.1.**
3505. ——— Lehrbuch der entwicklungsgeschichte des menschen und der wirbelthiere; vierte auflage. Jena, xiv, 590 p., 2 pls. 8vo. **93 1.**
3506. Marshall, A. M. Vertebrate embryology. London and New York, xxiii, 640 p. 8vo. **93.1.**
3507. Wiedersheim, R. Grundriss der vergleichenden anatomie der wirbelthiere. Jena, xx, 695 p., 4 pls. 8vo. **93 1.**

THYMUS AND THYROID.

3508. Antipa, Gr. Ueber die beziehungen der thymus zu den sog. kiemenspaltenorganen bei selachiern. Anat. anz., vii, 690 692. **92.1.**

3509. Capobianco, F. Contribuzioni alla morfologia del timo. Giorn. assoc. nat. e med., ii, 1-24, pl. i. Translation: Arch. ital. biol., xvii, 55-63. **91.1.**

3510. ——— Sur les fines altérations des centres nerveux et des racines spinales par suite de la thyréoidectomie. Arch. ital. biol., xviii, 306-312. **92.1.**

3511. Tourneux, F., *and* Herrmann, G. Sur l'évolution histologique du thymus chez l'embryon humain et chez les mammifères. C. R. soc. biol., Paris, sér. 8, iii, 84-87. **87.3.**

3512. Waldeyer, W. Die rückbildung der thymus. Sitzb. preuss. akad. wiss. Berlin, 433-446. **90.2.**

3513. Weibgen, K. Zur morphologie der schilddrüse des menschen. München. med. abh., h. 14, 15 p. **91.1.**

TONGUE AND TASTE.

3514. Gmelin. Zur morphologie der papilla vallata und foliata. Arch. f. mikr. anat., xl, 1-28, taf. i. **92.1.**

3515. Lenhossék, M. v. Der feinere bau und die nervenendigungen der geschmaehsknospen. Anat. anz., viii, 121-127. **93.1.**

TOUCH.

3516. Dogiel, A. S. Die nervenendigungen in Meissner'schen tastkörperchen. Intern. monatsschr. f. anat. u. phys., ix, 76-85, taf. v. **92.4.**

TUNICATES.

3517. Davidoff, M. v. Ueber den canalis neurenterieus anterior bei den ascidien. Anat. anz., viii, 301-303. **93.1.**

UMBILICAL CORD.

3518. Keibel, Franz. Ueber den nabelstrang des nilpferdes. Anat. anz., viii, 497-504. **93.2.**

UROGENITAL.

3519. Amann, J. A., Jr. Beiträge zur morphogenese der Müller'schen gänge und über accessorische tubenostien. Arch. f. gynäk., xlii, 133-191, taf. ii-v. **92.1.**

3520. Boveri, Theod. Die nierencanälchen des Amphioxus; ein beitrag zur phylogenie des urogenitalsystems der wirbelthiere. Zool. jahrb., abth. anat., v, 429-510, taf. xxxi-xxxiv. **92.2.**

3521. Hoffmann, C. K. Étude sur le développement de l'appareil uro-génital des oiseaux. Verh. akad. v. wetensch. Amsterdam, i, 54 p. pls. i-vii. **92.2.**

3522. Nagel, W. Ueber die entwickelung der urethra und des dammes beim mensehen. Arch. f. mikr. anat., xl, 264-286, taf. xv. **92.2.**

3523. Regnauld, E. Études sur l'évolution de la prostate chez le chien et chez l'homme. Journ. anat. et phys., xxviii, 109-128. **92.1.**

3524. Retterer, E. de. Sur la morphologie et l'évolution de l'épithélium du vagin des mammifères. Mém. soc. biol. Paris, sér. 9, iv. 101-107. **92.2.**

UTERUS.

3525. Pestalozza, E. Anatomia dell' utero umano in gravidanza ed in travaglio. Milano, 8 p., 8vo. 9 pls. fol. **92.1.**

VEINS.

3526. Hochstetter, Fr. Ueber die hintere hohlvene. Verh. anat. ges. Wien, vi, 181. **92.1.**

3527. ——— Beiträge zur entwicklungsgesehiehte des venensystems der amnioten; ii. Reptilien (Lacerta, Tropidonotus). Morph. jahrb., xix, 428-501, taf. xv-xvii. **92.3.**

3528. Rathke, H. Ueber den bau und die entwickelung des venensystems der wirbelthiere. Ber. naturw. seminar univ. Königsberg, iii, 23 p. **38.3.**

3529. Rex, Hugo. Beiträge zur morphologie der hirnvenen der amphibien. Morph. jahrb., xix, 295-311, taf. xi. **92.1.**

3530. Zander, V. R., *and* Stieda, H. Persistenz des urnierenteiles der linken kardinalvene beim erwachsenen. Anat. hefte, abth. 1, h. iii, 129-140, taf. ix. **92.1.**

VERTEBRAE.

3531. Ebner, V. von. Ueber die beziehungen der wirbel zu den urwirbeln. Sitzb. Wien. akad., ci, abth. 3, 235-260, 1 taf. **92.1.**

3532. Gegenbaur, C. Untersuchungen zur vergleichenden anatomie der wirbelsäule bei amphibien und reptilien. Leipzig, iv, 72 p., 4 pls. 4to. **62.2.**

3533. Hasse, C. Die entwickelung der wirbelsäule von Triton taeniatus; erste abhandlung über die entwicklung der wirbelsäule. Zeitschr. wiss. zool., liii, suppl., 1-20, taf. iii. **92.1.**

3534. ——— Die entwicklung der wirbelsäule der ungeschwanzten amphibien; zweite abhandlung über die entwicklung der wirbelsäule. Zeitschr. wiss. zool., lv, 252-264, taf. xii. **92.2.**

3535. ——— Die entwicklung der wirbelsäule der elasmobranchier; dritte abhandlung über die entwicklung der wirbelsäule. Zeitschr. wiss. zool., lv, 519-531, taf. xxi. **92.3.**

3536. ——— Allgemeine bemerkungen über die entwickelung und die stammesgeschichte der wirbelsäule. Anat. anz., viii, 288-289. **93.1.**

3537. ——— Die entwickelung der wirbelsäule der Dipnoi; vierte abhandlung über die entwickelung der wirbelsäule. Zeitschr. wiss. zool., lv, 533-543, taf. xxii. **93.2.**

3538. Jordan, D. S. Relations of temperature to vertebrae among fishes. Proc. U. S. nat. mus., xiv, 107-120. **91.1.**

3539. Klaatsch, H. Beiträge zur vergleichenden anatomie der wirbelsäule; i. Ueber den urzustand der fischwirbelsäule. Morph. jahrb., xix, 649-680, taf. xxvi. **93.1.**

3540. Macalister, A. Notes on the development and variations of the atlas. Journ. anat. phys. norm. path., xxvii, 519-542. **93.1.**

3541. Ruge, G. Der verkürzungsprozess am rumpfe von halbaffen. Morph. jahrb., xviii, 185-326, taf. vii-x. **92.1.**

3542. Scheel, C. Beiträge zur entwickelungsgeschichte der teleostier-wirbelsäule. Morph. jahrb., xx, 1-47, taf. i-iii. **93.1.**

3543. Wirth, Alex. Zur anatomie und entwickelungsgeschichte des atlas und epistropheus. Leipzig, 24 p., 1 pl. 8vo. **84.1.**

VERTEBRATES.

3544. Hertwig, Oscar. Urmund und spina bifida. Arch. f. mikr. anat., xxxix, 353-503, taf. xvi-xx. **92.1.**

WOLFFIAN BODY.

3545. Dieffenbach, E. Quaestiones anatomico-physiologicae de corporibus Wolffianis. Turici, 27 p. 8vo. **36.1.**

3546. Farrington, O. C. The nephrostomes of Rana. Trans. Conn. acad., viii, 309-314, pl. xxiv. **92.1.**

3547. Field, H. H. Ueber streng metamere anlage der niere bei amphibien. Verh. deutsch. zool. ges., 2. vers. Berlin, 113-117. **92.1.**

3548. Nicolas, A. Contribution à l'étude des cellules glandulaires; i. Les éléments des canalicules du rein primitif chez les mammifères. Intern. monatsschr. f. anat. u. phys., viii, 279-292, 387-413, 447-464, 465-509, taf. xxvi-xxix. **91.1.**

YOLK SAC.

3549. Bersch, Karl. Die rückbildung des dottersackes bei Lacerta agilis. Anat. hefte, abth. 1, h. iii, 475-503, taf. xxix-xxx. **93.1.**

3550. Buchanan, A. M. Diverticulum (Meckel's) of small intestine. Journ. anat. phys. norm. path., xxvii, 559-563. **93.1.**

3551. Lamb, D. S. The Meckel diverticulum. Am. journ. med. sc., cv, 633-641. **93.1.**

3552. Rogie. Anomalies de régression du canal vitellin; diverticule de Meckel. Journ. sc. med. Lille, ii, 385, 409. **92.1.**

3553. Staurenghi, C. Sulla sede e natura della pimmentazione verde del sacco vitellino della Crocidura leucodon (Hermann). Arch. sc. med. Torino e Palermo, xv, 291-295, 1 pl. **91.1.**

3554. Virchow, H. Das dotterorgan der wirbelthiere. Arch. f. mikr. anat., xl, 39-101, taf. iii-iv. **92.2.**

3555. ——— Dotterzellen und dotterfurchung bei wirbeltieren. Verh. anat. ges. Wien, vi, 209-219. **92.3.**

Note.— Advantage has been taken of the opportunity to make a large addition consisting of titles of publications issued since the manuscript of the main list was prepared, and also of earlier publications which I had previously overlooked or been unable to verify. I have again to thank Dr. J. S. Billings for his invaluable co-operation in securing for me numerous verifications. My thanks are also due to Mr. Samuel Henshaw for generous assistance.

The present bibliography as it now stands contains about seven times the number of titles to be found in any previous bibliography of the subject, known to me; nevertheless it is far from complete. I shall be grateful for any additions or corrections. Under those heads not strictly included within the scope of Vertebrate Embryology, no attempt at completeness is made, or thought advisable.

The numbers in heavy type at the end of each title indicate the year of publication and the number for that year and author, thus: 3083. Marotta, . . . **88.1** means the article was published in 1888, and was the first article by Marotta to be catalogued for that year. The same system is used throughout my "Human Embryology."

INDEX OF AUTHORS.

Abel, K. — Tubal pregnancy, 2870.
Acconci, L. — Uterus, 2968-2969.
Ackeren, F. van. — Urogenital, 2895.
Ackermann, Th. — Placenta, 2065.
Aeby, Ch. — Bone, 279— Epidermis, 602.
Afanasieff. — Blood, 154 — Heart, 1099.
Afanassiew, B. — Thymus and thyroid, 2837-2838.
Agassiz, A. — Ganoids, 3207.
Agassiz, A., *and* Whitman, C. O. — Teleosts, 2756-2758.
Ahlborn, F. — Pineal gland, 2040 — Segmentation of body, 2313.
Ahlfeld, F. — Allantois, 1 — Amnion, 21-23 — Atavism, 125 — Decidua, 502-503 — Human embryo, 1154 — Nutrition of embryo, 1856 — Placenta, 2066 — Twins, 2874-2875 — Yolk sac, 3068-3069.
Albrecht, P. — Evolution of man, 641 — Hypophysis, 1214.
Allen, W. — Yolk sac, 3070.
Altmann, R. — Cell theory, 3156-3157 — Cells, 384 — Nerves, 1672.
Aly, W. — Blood, 155.
Amann, J. A., Jun. — Urogenital, 3519.
Ammon, von. — Eye, 698.
André, J. — Micropyle, 1583.
Angelucci, A. — Eye, 700.
Annell, G. — Teeth, 3466.
Antipa, Gr. — Thymus and thyroid, 3508.
Antonelli, A. — Nerves, cephalic, 1707.
Antonini, A. — Hemispheres, cerebral, 3239a.
Arnold, A. F. — Ovum, 3366.
Arnold, G. — Ovulation, 1919.
Arnold, J. — Blood, 156 — Blood vessels, 255-257 — Eye, 699 — Heart, 1100.
Aschoff, A. — Arteries, 3100.
Assaky, G. — Germ layers, 938 — Mouth, 1588.
Assheton, R. — Eye, 3192.
Aswadouroff, K. — Muscles, 1594.
Aubert. — Heart, 1101 — Teleosts, 2759.
Auerbach, L. — Blood, 157 — Intestine, 3267-3268 — Sex, 3430 — Sexuality, 2382-2383.
Auvard, A. — Ovulation, 1920 — Placenta, 2067.
Ayers, H. — Blood vessels, 258 — Ear, 541-542, 3170-3172 — Head, 1075.
Babuchin. — Eye, 701.
Baer, K. E. von. — Amphibia, 58 — General works, 842 — Gill clefts, 1030-1031 — Ovum, 1931 — Placenta, 2068 — Reptiles, 2277 — Teleosts, 2760.
Baginsky, A. — Meconium, 1564.
Baginsky, B. — Ear, 543.
Balbiani, G. — General works, 843.
Balbiani, M. — Ovum, 1932.
Balfour, F. M. — Blood, 158 — Elasmobranchs, 584-586 — Germ layers, 939-941 — Head kidney, 1087-1089 — Invertebrates, 1320 — Limbs, 1379 — Nerves, 1673-1675 — Ovary, 1866 — Ovum, 1933 — Placenta, 2070 — Reptiles, 2278 — Supra-renals, 2680 — Vertebrates, 3031.
Balfour, F. M., *and* Deighton, F. — Germ layers, 942.
Balfour, F. M., *and* Parker, W. N. — Ganoids, 827.
Balfour, F. M., *and* Sedgwick, A. — Head kidney, 1087-1088.
Ballowitz, E. — Spermatozoa, 2591-2597, 3450 — Teeth, 3467.
Bambeke, C. v. — Amphibia, 59 — Cells, 385-386 — Connective tissue, 482-483 — Eye, 702 — Germ layers, 943 — Heredity, 1128 — Mammals, 1451 — Ovum, 1934-1939 — Segmentation of ovum, 2319 — Teleosts, 2761-2763.
Banks, W. M. — Wolffian body, 3040.
Bardeleben, K. von. — Limbs, 1380 — Muscles, 1595 — Skeleton, 2404 — Spermatozoa, 2598, 3451.
Barfurth, D. — Heredity, 3245 — Muscles, 1596 — Notochord, 1821.
Barkau, A. — Eye, 703.
Barnes, W. — Spinal cord, 2644.
Barry, M. — General works, 844-846.
Barth. — Intestine, 1300.
Bassett, J. — Placenta, 2071.
Bateson, W. — Evolution of man, 642.
Baudouin, M. — Human embryo, 1155.
Baume. — Placenta, 2069.
Baumgarten, H. — Ear, 3173.
Baumüller, B. — Skeleton, 2405.
Baur, G. — Evolution of man, 643, 3188 — Limbs, 1381 — Skeleton, 2406-2411.
Bayer. — Placenta, 2072.
Bayer, L. — Arteries, 3101.
Bayerl, B. — Blood, 159.
Beard, J. — Ganoids, 828 — General works, 3208 — Mouth, 1589 — Nerves, 1676-1677 — Nerves, cephalic, 1708-1709 — Nervous tissue, 1738-1739 — Neuron, 1784-1785 — Pineal gland, 2041-2042 — Wolffian body, 3041.
Beauregard, H. — Spermatogenesis, 2540 — Urogenital, 2896.
Beauregard, *and* Boulart. — Placenta, 2073.
Bechterew, W. — Cerebellum, 462 — Spinal cord, 2645.
Béclard, — Skeleton, 2412.
Beddard, F. E. — Allantois, 2 — Ovum, 1940-1941.
Bedot, M. — Nerves, 1678.
Behn. — Epidermis, 3184.
Beigel, H. — Human embryo, 1156 — Ovary, 1867 — Wolffian body, 3042.

Beigel, *and* Löwe.— Human embryo, 1157.
Bellonci, G.— Germ layers, 944— Ovum, 1942-1943— Segmentation of ovum, 2320—Spermatozoa, 2599.
Bellonci, G., *and* Stefani, — Brain, 309a.
Bellonci, J.—See, Bellonci, G.
Below, E.— Brain, 310.
Beltzow, A.— Tendon, 2821.
Bemmelen, J. F. van. — Gill clefts, 1032-1034 — Heredity, 1129— Muscles, 1597.
Benckiser, A. — Ovary, 1868.
Benda, C.— Spermatogenesis, 2541 — Spermatozoa, 2600-2601, 3452 — Testis, 2825.
Benecke, B.— Ovum, 1944.
Beneden, E. v. — Germ layers, 945 — Impregnation, 1223-1226 — Mammals, 1452-1453 — Ovary, 1869— Ovum, 1945-1946— Placenta, 2074-2075 — Sexuality, 2384 — Teleosts, 2764.
Beneden, E. v., *and* Julin, Ch.— Foetal membranes, 777 — Gill clefts, 1035 — Impregnation, 1227 — Segmentation of ovum, 2321 — Spermatogenesis, 2542.
Beneden, E. van, *and* Neyt, A.— Impregnation, 1228.
Béraneck, E.—Nerves, cephalic, 1710 — Pineal gland, 2041, 3381.
Berchon, E., *and* Périer, L. — Blood, 160.
Berg, E.— Ovum, 1947.
Bergmann.— Segmentation of ovum, 2322-2323.
Bergmeister, O.— Eye, 704.
Bergonzini, C.— Foetal membranes, 778— Spermatogenesis, 2543.
Berkley, H. J. — Cerebellum, 3161
Bernard, C.— Placenta, 2076.
Bernays, A.— Heart, 1102 — Joints, 1356a.
Berner, H. J.— Sex, 2358.
Bernhardt, A.— Ovum, 3367.
Bernheimer, S.— Eye, 705.
Berry, H. D. — Birth, 139.
Bersch, K.— Yolk sac, 3549.
Bertè, F., *and* Cuzzi, A.— Ovary, 1870.
Bertolet, R. M.— Blood, 161.
Bertrand, Camille.— Skull, 2474.
Besser.— Nervous tissue, 1740.
Bianchi, S.— Skull, 2475, 3436.
Bidder, A. A.— Skull, 2476.
Bidder, F., *and* Kupffer, C.— Spinal cord, 2646.
Biehringer, J.— Mammals, 1454-1455.
Bierfreund, Max.— Placenta, 2077—Urogenital, 2896a.
Biondi, D.— Spermatogenesis, 2544-2545.
Birdsall, W. R.— Sympathetic, 2691.
Bischoff, Th. L. W.—Brain, 311—Foetal membranes, 779— General works, 847 — Impregnation, 1229-1230, 3263— Mammals, 1456-1464— Menstruation, 1580— Ovulation, 1921, 3363— Ovum, 1948-1950.
Bizzozero, G.— Blood, 162-163—Fat, 765—Intestine, 1301-1302, 3269-3273— Marrow of bone, 1545-1546.
Bizzozero, G., *and* Vassale, G.— Intestine, 3274.
Bizzozero, J.— Blood, 164.
Bizzozero, J., *and* Torre, A.— Blood, 165.
Bizzozero, J., *and* Vassale, G.— Intestine, 1303.
Blacher, K.— Foetal membranes, 780-781.
Blackwell, A. P.— Sex, 2359.
Blake, C. J.— Ear, 544.
Blake, J. E.— Skull, 2477.
Blanc, E.— Uterus, 2970.
Blanc, L.— Birds, 3104.
Blanchard, R.— Biogenesis, 126— Impregnation, 1231.
Blaschek, A.— Heart, 1103.
Blaschko, A.—Epidermis, 603-604.
Blaue, J.— Nose, 1802.
Bloch, Louis.— Placenta, 2078.
Blochmann, F.— Ovum, 1951-1955.
Blomfield, J.—Spermatogenesis, 2546-2548.
Blumenau, L.— Brain, 312.
Boas, J. E. V.— Aorta, 107 — Genitalia external, 929 — Nails, 1665 — Teeth, 2702.
Bobritzky, C.— Blood vessels, 259—Fat, 766.
Böhm, A. A.— Impregnation, 1232-1234, 3264.
Böttcher, A.— Blood, 166— Ear, 545.
Bojanus, L.— Mammals, 1465.
Boldt, H. J.— Decidua, 504.
Boll, Fr.— Growth, 1057 — Nervous tissue, 1741— Spinal cord, 2647— Teeth, 2703.
Bonnet, R. — Foetal membranes, 782-783— General works, 848—Hairs, 1069-1070—Mammals, 1466-1470— Uterus, 2971—Wolffian body, 3043.
Borden, W. C.— Fat, 767.
Born, G.—Heart, 1104-1105—Hybrids, 1211-1212—Impregnation, 3265— Muscles, 1598— Nose, 1803-1805— Segmentation, 3417 — Segmentation of ovum, 2324 — Thymus and thyroid, 2839
Bornhaupt, Th.— Urogenital, 2897.
Borsenkow.— Urogenital, 2898.
Bossi, L. M., *and* Conti, A.— Placenta, 2079.
Bouch, C. — Human embryo, 1158.
Bouillet. — Growth, 1058.
Bouillon, L. — Meconium, 1565.
Boulart, B. — Placenta, 2080.
Bourne, A. G. — Sexuality, 2385.
Boveri, Th. — Amphioxus, 86, 3089 — Heredity, 3246 — Impregnation, 1235-1237 — Ovum, 1956 — Segmentation of ovum, 2325 — Sex, 2360 — Urogenital, 3520.
Bowen, J. T. — Epidermis, 605.
Boyer, E. R. — Limbs, 3290.
Bramann, F. — Testis, 2826.
Brand, E. — Stomach, 2670.
Brandt, A. — Germ layers, 946-947.
Brandt, E. — Growth, 1059.
Brass, A. — Cells, 387.
Brauer, A. — Cell division, 3147.
Braun, M. — Birds, 127-129 — Supra-renals, 2681 — Tail, 2698-2699 — Twins, 2876 — Urogenital, 2899.
Braune, W. — Brain, 313.
Braune, W., *and* Zweifel, P.— Gestation, 1026.
Braxton, Hicks. — See, Hicks, J. B.
Brazzolo, F. — Testis, 2827.
Bremer, L. — Muscles, 1599.
Breschet, G. — Foetal membranes, 784 — Placenta, 2083.
Breslauer, W. — Connective tissue, 484.
Breus, K. — Human embryo, 1158.
Broca, A. — Face, 760.
Brock, J. — Bone, 280 — Face, 761 — Spermatozoa, 2602-2603 — Urogenital, 2900-2901.
Bronn, H. H. — Spermatogenesis, 2549.

Brook, G. — Germ layers, 948-949 — Head kidney, 1090 — Teleosts, 2765-2766.
Brooks, W. K — Segmentation of ovum, 2326.
Bruch, C. — Heart, 3237 — Human embryo, 1158a — Skeleton, 2413.
Bruch, C., *and* Siebold, C. Th. von. — Micropyle, 1584.
Brunn, A. von.— Spermatogenesis, 2550 — Spermatozoa, 2604 — Supra-renals, 2682 — Teeth, 2704-2706.
Brunn, M. v. — Spermatozoa, 2605.
Brutenbach, W. — Sexuality, 2386.
Buchanan, A. M. — Yolk sac, 3550.
Budge, A. — Allantois, 3 — Germ layers, 950 — Lymphatics, 1428-1429.
Budin, *and* Chaignot.— Heart, 1106.
Bürger, O. — Cell division, 424-425, 3148.
Bütschli, O. — Blood, 167 — Conjugation, 477-478 — Gastrula theory, 836 — Ovum, 1957 — Protoplasm, 2268-2270 — Sexuality, 2387.
Bütschli, O., *and* Schewiakoff, W. — Muscles, 1600.
Bufalini, G.— Spinal cord, 2648.
Bujor, P. — Marsipobranchs, 3311.
Bumm, E.— Pineal gland, 3383-3385 — Placenta, 2084-2087.
Burckhardt, R. — Germ layers, 951.
Butler, G. W. — Coelom, 468.
Buzzi, F. — Epidermis, 606.
Cadiat, O. — Allantois, 4 — Diaphragm, 531-532 — Gill clefts, 1036 — Urogenital, 2902 — Uterus, 2972.
Cajal, S. Ramón y. — Brain, 3134 — Cerebellum, 463 — Hemispheres, 3240 — Nervous tissue, 1742-1743.
Calberla, E. — Impregnation, 1238 — Muscles, 1601 — Neuron, 1786.
Calderara, G. — Muscles, 3323.
Calderwood, W. L. — Head kidney, 1091 — Ovary, 3359.
Caldwell, W. H. — Foetal membranes, 785 — Mammals, 1471-1472 — Segmentation of body, 2314.
Call, E. L., *and* Exner, S. — Ovary, 1871.
Callender, G. W. — Blood vessels, 260 — Brain, 314 — Face, 762.
Camerano, L. — Mammals, 1473.
Campana, M.— Intestine, 1304 — Spermatozoa, 2606.
Campbell, D. H. — Spermatogenesis, 2551.
Canalis, P. — Teeth, 2707.
Cane, F. — Amnion, 24.
Capobianco, F. — Thymus and thyroid, 2840, 3509-3510.
Carini, A. — Ovum, 1958.
Carius, F. — Mammals, 1474-1475 — Notochord, 1823.
Carlier, E. W. — Notochord, 1822.
Carlier, O. — Skeleton, 2414.
Carnoy, J. B. — Cells, 388 — Ovum, 1959-1961.
Carus, C. G.— General works, 849.
Cattani, G.— Muscles, 1602.
Canivenberghe, C. van — Placenta, 2088.
Chabry, L , *and* Boulart, P.— Foetal membranes, 786.
Chadwick, J. R — Birth, 140.
Chaille, S. E.— Evolution of man, 644.
Champeil, J.— Skull, 2478.
Chapman, H. C.— Foetal membranes, 787-788 — Placenta, 2089-2090.
Châtellier, H. — Placenta, 2091.
Chiarugi, G.— Human embryo, 1159-1160 — Myotomes, 1653 — Nerves, 1679 — Nerves, cephalic, 1711-1713, 3332.
Chievitz, J. H. — Eye, 3192a-3192b — Lymphatics, 1430— Salivary glands, 2311 — Text-books, 3503.
Cholodkovsky, N.—Blastopore, 144.
Christomanos, A. A., *and* Strössner, E.— Muscles, 3324.
Chun, Carl.— Cell division, 426.
Ciaccio, G. V.— Eye, 706, 3193.
Cirincione, G.— Eye, 3194.
Clapp, Cornelia M.— Teleosts, 2767.
Clark, H. J.— Reptiles, 2279.
Clarke, J. L.— Spinal cord, 2649-2650.
Clarke, S. F.— Amphibia, 60 — Reptiles, 2280 — Wolffian body, 3044.
Claus, C.— Gastrula theory, 837.
Cleland, J.—Brain, 315 — Evolution of man, 645 — Uterus, 2973.
Clevenger, S. V.— Neuron, 1787.
Cloetta, M.— Intestine, 3275.
Coblenz, H.— Uterus, 2974.
Cohen, H. M — Heredity, 1130.
Cohnstein.— Placenta, 2092.
Cohnstein, J., *and* Zuntz, N.— Mammals, 1476 — Nutrition of embryo, 1857.
Colucci, V. — Placenta, 2093.
Cope, E. D.—Evolution of man, 646-650— Skeleton, 2415-2416 — Skull, 3437 — Teeth, 2708-2709.
Cori, C. J.—Metamerism, 3318.
Corning, H. K.—Blood, 168—Nervous tissue, 1741—Skeleton, 2417.
Corridi, G.— Bone, 3132.
Coste, J. J.— Decidua, 505 — General works, 850-851— Placenta, 2094.
Coste, P.—Allantois, 5.
Creighton, Ch.—Mammae, 1435— Placenta, 2095-2096.
Cristiani, H.— Rodents, 3415.
Cruikshank, W.— Mammals, 1477.
Cuccati, G.— Spermatogenesis, 2552.
Cuénot, L.—Blood, 169, 3110.
Cunningham, D. J.—Brain, 316-318.
Cunningham, J. T.— Cell division, 427 — Germ layers, 952-954—Marsipobranchs, 1548 — Spermatogenesis, 2553— Teleosts, 2768-2769.
Curie, E.— Placenta, 2097.
Curtis, F.— Mammae, 1436— Nails, 1666.
Cusset, J.—Gill clefts, 1037.
Czazan.— Menstruation, 1581.
Czermak.— Spermatozoa, 2607.
Czermak, J.— Teeth, 2710.
Czermak, N.— Bone, 281.
Czerny, A.—Wolffian body, 3045.
Dall, W. H.— Evolution of man, 651.
Dalrymple.— Placenta, 2098.
Dalton, J. C.— Ovary, 1872-1873.
Dana, J. D.— Evolution of man, 652.
Dansky, J., *and* Kostenitsch, J.— Germ layers, 955.
Dareste, C.— Birds, 130, 3105 — Heart, 1107 — Intestine, 1305 — Mesentery, 3316—Placenta, 2099— Teratology, 3491.
Darin, Ch.— Heredity, 1131.
Dastre, A.— Allantois, 6.
Davenport, C. B.— Arteries, 3102.
David, J.— Nerves, cephalic, 3333.

Davidoff, M. v.—Blood, 170—Germ layers, 3215—Intestine, 1306—Limbs, 1382—Tunicates, 2872, 3517.
Debierre, Ch.—Bladder, 143a — General works, 852 — Limbs, 1383.
Decker, F.— Skull, 2479.
Dehner, H.— Segmentation, 3418.
Deiters, O.— Muscles, 1603.
Delaunay, G.— Uterus, 2975.
Delore.— Placenta, 2100.
Demon, F. — Intestine, 1307.
Deniker, J. — Mammals, 1478-1480.
Denys, J. — Blood, 171 — Cell division, 428.
Deschamps. — General works, 853.
Dentschmann, R. — Elastic tissue, 599.
Dewitz, J. — Impregnation, 1239-1240.
Dexter, Samuel. — Myotomes, 1655.
Dieffenbach, E. — Wolffian body, 3545.
Disse, J. — Blood, 172-173 — Germ layers, 956 — Nose, 1806.
Dixey, F. A. — Bone, 282.
Dobbert, Th. — Tubal pregnancy, 2871.
Dobrynin, P. v. — Allantois, 7.
Döderlein. — Amnion, 25-26 — Amniotic fluid, 48.
Dönhoff. — Epidermis, 607.
Dönitz, W. — Germ layers, 957.
Dogiel, A. S. — Eye, 707-708 — Medullary nerve cell, 3314 — Retina, 3412 — Touch, 3516.
Dohrn, A. — Blood vessels, 261 — Evolution of man, 653-658 — Eye, 709 — Foetal membranes, 789 — Gill clefts, 1038-1039 — Head, 1079-1080 — Limbs, 1384 — Mouth, 1590 — Muscles, 1604 — Nerves, 1680-1681 — Nervous tissue, 1745 — Skeleton, 2418 — Thymus and thyroid, 2841-2842 — Wolffian body, 3046.
Dohrn, F. A. R. — Uterus, 2976-2978.
Dohrn, H. — Umbilical cord, 2881.
Doléris, A., *and* Quindquand. — Blood, 174.
Dollo, J. — Skull, 2480.
Dollo, M. L.— Skeleton, 2418.
Dostoiewsky, A.— Supra-renals, 2683.
Driesch, H.— Segmentation of ovum, 2327, 3419.
Drogoul — Bone, 283.
Düsing, K.— Sex, 2361-2362.
Dugès, A.— Placenta, 2101.
Dujardin, F.— Spermatozoa, 2608.
Duncan, J. M.— Placenta, 2102 — Pregnancy, 2258.
Duncan, M.— Decidua, 506.
Durand, G.— Eye, 3195.
Durante, F.— Ovum, 1962.
Durham, H. E.— Connective tissue, 485 — Neurenteric canal, 1773.
Dursy, E.— Brain, 319-320 — Germ layers, 958—Wolffian body, 3047.
Duval, M.— Eye, 710 — Foetal membranes, 790 — General works, 854 — Germ layers, 959-960 — Hairs, 1071 — Pineal gland, 3382 — Placenta, 2103-2112, 3386-3389 — Uterus, 2979.
Eberth, C. J.— Blood, 175 — Blood vessels, 3123-3124 — Impregnation, 1241.
Eberth, C. J., *and* Aly, W.— Blood, 176.
Ebner, V. v.— Myotomes, 1656 — Spermatogenesis, 2554 — Spermatozoa, 2609-2610 — Teeth, 2711-2712 — Vertebrae, 3531.
Eckardt, C. Th.— Placenta, 2113.
Ecker, A.— Brain, 321-323 — General works, 855 — Human embryo, 1161-1164.
Edinger, L.— Brain, 324-325, 3135.
Edwards, A. Milne.— Mammals, 1481 — Placenta, 2114.
Egli, Th.— Urogenital, 2903.
Ehlers, E.— Notochord, 1824 — Pineal gland, 2044.
Ehrlich, F.— Myotomes, 1657.
Ehrmann.— Pigment cells, 3380.
Eichbaum, F.— Genitalia external, 930.
Eichholz, A.— Arteries, 3103.
Eichhorst, H.— Spinal cord, 2651.
Eigenmann, C. H.— Micropyle, 1585— Teleosts, 2770.
Eimer, G. H. T.— Evolution of man, 659 — Muscles, 1605 — Ovum, 1963 — Spermatozoa, 2612.
Elischer, J — Uterus, 2980.
Emanuel, R.— Foetal membranes, 791 — Twins, 2877.
Emery, C.— Heredity, 3247 — Kidney, 1359-1360 —Limbs, 1385-1386 — Skeleton, 2420.
Emmert, *and* Hochstetter.— Reptiles, 2281.
Endres, H.— Intestine, 3276.
Engelmann, G. J.— Decidua, 507.
Erb, W.— Blood, 177.
Ercolani, G. B.— Decidua, 508-509 — Placenta, 2115-2125.
Erdl, M. P.— General works, 856.
Erlanger, R. von.— Blastopore, 145-146.
Eschricht, D. F.— Nutrition of embryo, 1858.
Etzold, F.— Testis, 2828.
Evetzky, Th. v.— Eye, 711-712 — Nose, 1807.
Ewald, A.— Elastic tissue, 600.
Ewart, J. C.— Electric organ, 3183 — Lateral line, 3287.
Ewart, J. C., *and* Mitchell, J. C.— Lateral line, 3288.
Eycleshymer, A.— Pineal gland, 2045.
Falchi.— Eye, 713-714.
Fano, G.— Heart, 1108.
Farre, A.— Uterus, 2981.
Farrington, O. C.— Wolffian body, 3546.
Fasola, G.— Birds, 131.
Fauvel.— Larynx, 1373.
Favre, A.— Placenta, 3390.
Fehling, H.— Amniotic fluid, 49 — Growth, 1060 — Skeleton, 3431.
Felix, W.— Head kidney, 1092 — Liver, 3294 — Muscles, 1606-1607 — Urogenital, 2904.
Fellner, L.— Anus, 97.
Ferrari, C.— Spermatogenesis, 2555.
Fick, A. E.— Skeleton, 2421.
Fick, R.— Impregnation, 3266.
Field, G. L.— Spermatogenesis, 3443.
Field, H. H.— Head kidney, 1093 — Wolffian body, 3547.
Fischelis, Ph.— Thymus and thyroid, 2843.
Fiserius, E.— Mammals, 3304.
Flechsig, P.— Spinal cord, 2652.
Fleischer, R.— Nose, 1808.
Fleischmann, A —Amnion, 27 — Evolution of man, 660 — Placenta, 2126-2127, 3391—Stomach, 3458—Teeth, 2713.

Flemming, W.— Blood, 181 — Cell division, 429-433— Cells, 389-390, 3146—Connective tissue, 486— Fat, 768-770—Glands, 1055 —Lymphatics, 1431-1432—Muscles, 1608— Nuclei, 3355— Ovum, 1964-1965 — Spermatogenesis, 2556-2557 — Spermatozoa, 2613 — Wolffian body, 3048.
Flesch, Max.— Brain, 326 — Pineal gland, 2046.
Flourens.— Placenta, 2128.
Flower, W. H.— Limbs, 1387—Teeth, 2714.
Foa, P.— Blood, 178-179.
Foa, P., *and* Salvioli, G. — Blood, 180.
Förster, A.— Meconium, 1566.
Fol, Hermann.—Cell division, 434—Human embryo, 1165-1167— Impregnation, 1242-1243 — Myotomes, 1658 — Segmentation of ovum, 2328 — Tail, 2700.
Foulis, J.— Ovary, 1874-1875.
Fox, L. W.— Face, 763.
Franck, L.— Epidermis, 608— Ovary, 1876 — Placenta, 2129— Urogenital, 2905.
Francotte, P.— Pineal gland, 2047-2048.
Franque, O. von— Muscles, 1609.
Fraser, A — Ear, 546 — Mammals, 1482.
Frenzel, J.— Cell division, 435-436, 3149 — Cells, 391 — Heredity, 1132.
Fresenius, R.— Meconium, 1567.
Freud, S.— Spinal cord, 2653.
Freund, M. B.— Coelom, 469.
Freund, P.— Teeth, 3468.
Friedländer, C.— Decidua, 510 — Uterus, 2982.
Fries, S.—Mammals, 1483-1484.
Frobeen, F.— Liver, 3295.
Frommann, C.— Cells, 392-396—Epidermis, 609-610—Fat, 771— Ovum, 1966-1967— Protoplasm, 2271— Segmentation of ovum, 2329.
Frommel, R.— Placenta, 2130-2132.
Froriep, A.— Eye, 715— Nerves, cephalic, 1714-1717—Neuromeres, 3348 — Notochord, 1825— Skeleton, 2422 — Skull, 2481-2482.
Fuchs, S.— Brain, 327.
Fürbringer, M.— Urogenital, 2906.
Fürst, C. M.— Spermatogenesis, 2558.
Funcke, E.—Blood, 182.
Funkhouser, R.— Sex, 2363.
Fusari, R.— Brain, 328— Segmentation of ovum, 2330 — Supra-renals, 3460 — Teleosts, 3488.
Gadow, H.—Genitalia external, 931— Gill clefts, 1040 — Urogenital, 2907.
Gage, S. H.— Blood, 183.
Gage, Susanna P.— Muscles, 1610.
Galeotti, G.— Cell division, 3150.
Ganghofner, F.— Larynx, 1374.
Garciar, A.— Hairs, 1072.
Gardiner, E. G.— Epidermis, 611.
Garnier, R. von— Gill clefts, 1041.
Garrod, A. H., *and* Turner, W.— Placenta, 2133.
Gaskell, W. H.— Evolution of man, 661— Nerves, 1682-1683—Nerves, cephalic, 1718.
Gasser, E.—Amphibia, 61—Anus, 98— Genitalia external, 932—Germ layers, 961-964—Heart, 1109— Urogenital, 2908-2910 — Uterus, 2983 — Wolffian body, 3049-3051.
Gaule, A. L.— Spleen, 3454.
Gaule, J.— Cells, 397-398 — Fat, 772 — Ganglia, 818 — Spinal cord, 2654.
Gaupp, E.— Skull, 2483, 3438-3439.
Geberg, A.— Cell division, 437.
Geddes, P.— Cells, 399 — Sex, 2364.
Geddes, P., *and* Thomson, J. A.— Sex, 2365— Spermatogenesis, 2559.
Gegenbaur, C.— Bone, 284-285— Epidermis, 612—Limbs, 1388-1390 — Mammae, 1437-1439 — Nerves, cephalic, 1719— Ovum, 1968-1969— Skeleton, 2423-2430— Skull, 2484-2485 — Vertebrae, 3532.
Gehuchten, A. van.— Brain, 3136 — Muscles, 1611-1612 — Nerves, cephalic, 3334 — Nose, 1809 — Ovum, 1970 — Sympathetic, 3463.
Gehuchten, A. van, *and* Martin, J.— Olfactory lobes, 3357.
Geigel, R.— Urogenital, 2911.
Gellé.— Ear, 547.
Gensch, H.— Blood, 184.
Gerbe, M. Z.— Segmentation of ovum, 2331.
Gerlach, L.— Brain, 329 — Elastic tissue, 601 — Heart, 1110 — Notochord, 1826 — Ovulation, 1922 — Twins, 2878.
Germano, E.— Testis, 3501.
Gervais, H. P.— Decidua, 511 — Placenta, 2134.
Geyl, A.— Birth, 141.
Giacomini, C.— Human embryo, 1168-1170, 3258 — Neurenteric canal, 1774 — Teratology, 2823-2824, 3492-3496.
Giacomini, E.— Foetal membranes, 3204 — Reptiles, 2282, 3403 — Salivary glands, 2312.
Giard, A.— Sex, 2366.
Gibbes, H.— Spermatozoa, 2614.
Gibson, G. A.— Heart, 1111, 3238.
Gibson, J. L.— Blood, 185.
Gierke, H.— Nervous tissue, 1746.
Giles, A. E.— Head kidney, 1094.
Gilis, P.— General works, 857.
Gilson, G.— Spermatogenesis, 2561.
Giovannini, S.— Hairs, 1073.
Giraldès, J. A.— Wolffian body, 3052.
Gmelin.— Tongue and taste, 3514.
Godet, R — Placenta, 2135.
Goehlert, V.— Sex, 2367.
Göhre, R.— Placenta, 3392.
Göppert, E.— Pancreas, 2034, 3373.
Goette, A.— Amphibia, 62-63 — Archenteron, 118 — Blood, 186 — Brain, 330 — Hairs, 1074 — Limbs, 1391 — Mammals, 1485 — Marsipobranchs, 1549 — Neuron, 1788 — Skeleton, 2431-2433 — Teleosts, 2771 — Vertebrates, 3032.
Goldberg, M.— Ganglia, 819.
Golgi, C.— Kidney, 1361 — Nerves, cephalic, 3335 — Nervous tissue, 747-748 — Olfactory lobes, 3358.
Golowine, F.— Ganglia, 820.
Golubew, Alex.— Blood vessels, 262.
Goodale, G. L.— Cells, 400.
Goodsir, J.— Placenta, 2136.
Goronowitsch, N.— Brain, 331 — Head, 3234 — Teleosts, 2772.
Gottschalk, S.— Placenta, 2137-2138, 3393 — Uterus, 2984.

Gottschau, M.—Eye, 716 — Supra-renals, 2684.
Günther, A. F.— Ear, 551.
Günther.— Testis, 2829.
Guesserow, A.— Amnion, 28-29.
Guignard, L.— Impregnation, 1244 — Sex, 2369.
Gulick, J. T.— Evolution of man, 663.
Gulland, G. L., *and* Hart, D. B.— Placenta, 3391.
Graaf, Regnerus de.— Ovary, 1877 — Pineal gland, 2049.
Gradenigo, G.— Ear, 548-549.
Gradenigo.— Ear, 550.
Graf, Spee.—See, Spee, Graf.
Grandis, V.— Spermatogenesis, 2562.
Granville, J. M.— Sex, 2368.
Grassi, B.— Skeleton, 2434.
Gray, Henry.— Spleen, 3455.
Gray, J. P.— Heredity, 1133.
Greenough, H. S.— Germ layers, 3216.
Grefberg, W.— Epidermis, 613.
Greman, M. J.— Placenta, 2139.
Grieg, J. A.— Gestation, 3228.
Grohe, F.— Ovary, 1878.
Grosglik, S.— Coelom, 470.
Grüber, A.— Blood, 187 — Conjugation, 479-480 — Evolution of man, 662.
Haacke, W.— Evolution of man, 661 — Mammals, 1486 — Ovum, 1971-1973.
Haberlandt, G.— Cells, 401.
Haddon, A. C.— General works, 858 — Mammals, 1487 — Wolffian body, 3053.
Haeckel, E.— General works, 859-862.
Häcker, V.— Polar globules, 3396 — Segmentation, 3420.
Haensche, C. C.— Marsipobranchs, 1550.
Haensell, P.— Eye, 717.
Hagen-Torn, O.— Synovia, 2695.
Haidenhain.—See, Heidenhain.
Haidlen, R.— Amnion, 30.
Halpryn, P.— Human embryo, 1172.
Hamann, O.— Germ layers, 965 — Sex, 2370.
Hamburger, O.— Kidney, 1362 — Pancreas, 3374.
Hamilton.— Brain, 332.
Hamy, E. T.— Brain, 333.
Hancock, J. L — Impregnation, 1245.
Handyside, P. D.— Heart, 1112.
Hanover, A.— Limbs, 1392 — Skull, 2486.
Hansemann, D.— Blood, 189 — Cell theory, 3158.
Hansen, J. A.— Yolk sac, 3071.
Hanstein, J. v.— Protoplasm, 2272.
Harmer, S. F.— Heredity, 3248.
Harnack, E.— Amnion, 31.
Hart, B. D., *and* Carter, J. T.— Foetal membranes, 792.
Hart, D. Berry.— Placenta, 2140 — Primates, 3399.
Hart, Mrs. E.— Blood, 190.
Harting, P.— Placenta, 2141-2142.
Hartog, M. M.— Sexuality, 2388-2389.
Harz, W.— Ovary, 1879.
Hasse, C.— Cartilage, 370-371 — Ovulation, 1923 — Skeleton, 2436 — Vertebrae, 3533-3537.
Hasse, C., *and* Born, G — Skeleton, 2137.
Hasse, C., *and* Schwarck, W.— Skeleton, 2438.
Haswell, W. A.— Birds, 132 — Muscles, 1613.
Hatschek, B.— Amphioxus, 87-89 — Invertebrates, 1321 1326—Limbs, 1393 — Metamerism, 3319-3320 — Sexuality, 2390-2391 — Skeleton, 2439.
Hatta, S.— Marsipobranchs, 3312.
Hausmann, U. F.— Ovum, 1974.
Haussmann —Decidua, 512.
Hay, O P.— Skull, 2487.
Haycraft, J. B — Reptiles, 3104.
Hayem, G.— Blood, 191.
Heape, W.— Mammals, 1488-1492.
Hegar.— Placenta, 2143.
Heidenhain, M.— Cell division, 438 — Germ layers, 3217.
Heidenhain, R.— Intestine, 1308, 3277.
Heinricius. — Placenta, 2144-2146.
Heintze.— Decidua, 513.
Heinz, R.— Placenta, 2147.
Held, H.— Nerves, cephalic, 3336 — Nervous tissue, 1749.
Heller, J.— Elasmobranchs, 3182.
Helme, A.— Uterus, 2985.
Henchman, Annie.— Invertebrates, 1327.
Henke, W., *and* Rehyer, C.— Synovia, 2696.
Henking, H.— Cells, 402 — Polar globules, 3397 — Spermatogenesis, 2563, 3444.
Henle, J.— Eye, 3196.
Hennegny, L. F.— Cell division, 439-440, 3151 — Germ layers, 3218 — Ovum, 3369 — Teleosts, 2773-2774.
Hennig, C.— Allantois, 8 — Foetal membranes, 793 — Growth, 1061 — Human embryo, 1173 — Ovulation, 3364— Placenta, 2148-2149.
Hensen, Victor.— Brain, 334 — Ear, 552-553 — General works, 863— Heredity, 1134— Impregnation, 1246 — Mammals, 1493-1495 — Nerves, 1684-1685 — Vertebrates, 3033.
Hepburn, D.— Joints, 1357.
Herbst, C.— Ovum, 3370.
Hermann, E. G.— Head, 1081.
Hermann, F.— Cells, 403 — Spermatogenesis, 2564— Testis, 2830 — Tongue and taste, 2860.
Hermann, G.— Spermatogenesis, 2565, 3445.
Herms, E.— Nervous tissue, 1750.
Herrick, C. L.—Brain, 3137-3138—Nerves, 3329—Nervous tissue, 3340.
Hertwig, O.—Cell division, 441—Connective tissue, 487—Ear, 3174 — General works, 864 — Germ layers, 966-967 — Impregnation, 1247-1253 — Segmentation of ovum, 2332 — Skeleton, 2440-2442 — Skull, 2488 — Testis, 3504-3505 — Vertebrates, 3544.
Hertwig, O , *and* Hertwig, R.— Coelom, 471— Impregnation, 1254-1255.
Hertwig, R.— Conjugation, 3105 — Impregnation, 1256-1257.
Herz, G.— Sex, 2371.
Herzfeld.— Nose, 1810.
Hesse, Fr.— Epidermis, 614.
Heynold.— Nails, 1667.
Hicks, J. B.— Placenta, 2081-2082, 2150.
Hickson, S. J.— Ovum, 1975.
Hill, Charles.— Pineal gland, 2050.
Hiltner, L.— Eye, 718.

His, W.—Birds, 133-134 — Brain, 335-339, 3139— Cervical sinus, 466 —Coelom, 472—Elasmobranchs, 587—Face, 3203 — General works, 865-872 — Germ layers, 968-970— Human embryo, 1174-1176—Lungs and trachea, 1418 —Mouth, 1591—Nerves, 1686-1688, 3330—Nerves, cephalic, 1720 — Nervous tissue, 1751-1752 — Ovary, 1880 —Spinal cord, 2655-2656— Tail, 2701— Teleosts, 2775-2777—Teratology, 3497 — Thymus and thyroid, 2844-2845— Vertebrates, 3034.

His, Wilhelm, Jun.—Nerves, cephalic, 1721—Sympathetic, 3464.

Hochstetter, F.— Arteries, 122-123 — Blood vessels, 263-266— Nose, 1811, 3350—Veins, 3022-3024, 3526-3527.

Hodge, C. F.— Medullary nerve cells, 3315.

Högyes, A.— Mammals, 1496.

Hofer, B.— Cells, 404.

Hoffmann, C. K.—Amnion, 32—Ear, 554—Elasmobranchs, 588— General works, 873— Germ layers, 971— Heart, 1113, 3239 — Impregnation, 1258 — Neuron, 1789— Notochord, 1827 — Reptiles, 2283-2285 — Skeleton, 2444— Teleosts, 2779-2783 — Urogenital, 2912-2913, 3521.

Hoffmann, E. F.— Nervous tissue, 1753.

Hoffmann, H.— Sexuality, 2392.

Hofmann, W.—Amniotic fluid, 50.

Hofmeier, M.— Placenta, 2151-2152—Uterus, 2986.

Hoggan, G., *and* Hoggan, Fr. E.—Fat, 773.

Holl, M.—Limbs, 1394, 3291—Ovum, 1976-1977—Placenta, 2153.

Hollard, H.—Placenta, 2154.

Holm, H.—Brain, 3140.

Holt, E. W. L.—Brain, 340.

Homburger.— Placenta, 2155.

Home, E.—Placenta, 2156-2157.

Hotz, Anna.—Amnion, 33.

Houssay, F.—Amphibia, 64-65, 3084— Blood vessels, 3125—Germ layers, 3219—Gill clefts, 1042—Intestine, 1309.

Houssay, F., *and* Battaillon.—Amphibia, 66-67.

Howe, G. B.— Intestine, 1310 — Limbs, 1395.

Howell, W. H.— Blood, 192-193 — Marrow of bone, 1547 —Spleen, 2637.

Howell, W. H., *and* Huber, G. C.— Nerves, 3331.

Huber, J. C. L.— Meconium, 1568.

Hubrecht, A. A. W.— Evolution of man, 665-666 — Germ layers, 972 — Mammals, 1497 — Nerves, 1689-1691 — Placenta, 2158-2159 — Skull, 2489.

Humphrey, G. M.— Muscles, 1614.

Humphry.— Skull, 2490.

Hun, Henry.— Human embryo, 3259.

Hunt, D.— Ear, 555 — Eye, 719.

Hunter, Wm.— Uterus, 2987.

Hurst, C. H.— Heredity, 3249-3250.

Huschke, E.— Eye, 720-721.

Huschke.— Gill clefts, 1043.

Huss, M.— Mammals, 1440.

Huxley, T. H.— Ear, 556 — Evolution of man, 667 — General works, 874 — Skeleton, 2445 — Skull, 2491-2492 —Teeth, 2715-2716.

Hyatt, A.— Evolution of man, 668 — General works, 875.

Hyrtl, J — Placenta, 2160.

Ide, Manille.— Cells, 405 — Epidermis, 615.

Imbert, G.— Uterus, 2988-2989.

Inaba, M.— Supra-renals, 3461.

Issmer, E.— Birth, 142.

Iversen, M.— Skeleton, 2446.

Iwakawa, T.— Ovum, 1978.

Jacobson, L. L.— Wolffian body, 3054.

Jägerskiold, M. L.— Hypophysis, 1215.

Janosik, J.— Blood vessels, 3126 — Human embryo, 1178 — Ovary, 1881—Supra-renals, 2685—Urogenital, 2914-2915.

Jarisch. — Epidermis, 616.

Jassinsky, P.— Placenta, 2161.

Jeffries, J. A.— Epidermis, 617.

Jensen, O. S.— Spermatogenesis, 2566 — Spermatozoa, 2615-2616.

Jhering, H. von.— General works, 876 — Skull, 2493.

Jörg, J. C. G.— General works, 877.

Johnson, Alice.— Blastopore, 147-148 — Limbs, 1396.

Johnson, Alice, *and* Sheldon, Alice.— Amphibia, 68.

Johnson, H. P.— Cell division, 442.

Johnstone.— Uterus, 2990.

Joly, N.— Placenta, 2162.

Jones, C. H.— Liver, 3296-3297.

Jones, T. W.— Blood, 194—Liver, 3298 —Mammals, 1498-1499.

Jordan, D. S.— Vertebrae, 3538.

Jordan, E. O.— Amphibia, 3085 — Impregnation, 1259.

Jordan, E. O., *and* Eycleshymer, A. C.— Segmentation, 3421.

Jourdain, S.— Birth, 143.

Julien, A.— Skeleton, 3432.

Julin, Ch.— Arteries, 124 — Marsipobranchs, 3313 — Nerves, cephalic, 1722 — Pineal gland, 2051.

Jungersen, Hector F. E.— Urogenital, 2916.

Junglöw, V. H.— Heart, 1114 — Reptiles, 2286.

Kaczander, J.— Bone, 286 — Intestine, 3278-3279 — Muscles, 1615-1616 — Nerves, cephalic, 1723 — Neuron 1790 — Skeleton, 2447.

Kazzander, G.— See, Kaczander, J.

Kaensche, C. C.— Marsipobranchs, 1550.

Kaestner, S.— Muscle, 3325 — Myotomes, 1659.

Kahlden, C.— Uterus, 2991.

Kahlweiss, F.— Decidua, 514.

Kallay, A.— Kidney, 1363.

Kann, M.— Notochord, 1828.

Kanthack, A.— Thymus and thyroid, 2846.

Kapf, H.— Ovary, 1882.

Karanyi, A.— Eye, 722.

Karg.— Epidermis, 618.

Kastchenko, N.— Elasmobranchs, 589 — Gill clefts, 1044-1045 — Limbs, 1397 — Ovum, 1979 — Placenta, 2163.

Keber, G. A. F.— Impregnation, 1260.

Kehr, J.— Ovulation, 1924.

Keibel, F.— Bladder, 143b — Blastopore, 149 — Eye, 723-724 — Human embryo, 1179-1181 — Mammals, 1500-1502 — Nose, 3351 — Notochord, 1829 — Placenta, 2164 — Tunicates, 3518.

Kennel, J. v. — Eye, 725.

Kerbert, C.— Epidermis, 619.
Kerschner, L.— Germ layers, 973 — Muscles, 3326-3327.
Kessler, L.— Eye, 726-729.
Ketel, H.— Larynx, 1375.
Key-Aberg, Algot.— Aorta, 3097.
Kidd, P.— Germ layers, 971.
Kielmeyer, D. C. F.— Evolution of man, 669.
Kieser, D. G.— Human embryo, 1182 — Intestine, 3280.
Killian.— Myotomes, 1660.
Kingsley, J. S.— Amphibia, 3086.
Kingsley, J. S., *and* Conn, H. W.— Teleosts, 2784.
Klaatsch, H.— Foetal membranes, 794 — Genitalia external, 3212 — Mammals, 1441 — Mesentery, 3317 — Testis, 2831 — Vertebrae, 3339.
Klebs, E.— Cells, 406 — Ovary, 1883-1884 — Placenta, 2165.
Klein, E.— Germ layers, 980 — Nerves, 1692 — Neuron, 1791 — Nose, 1812 — Placenta, 2166 — Teleosts, 2785.
Klein, G.— Decidua, 3168 — Uterus, 2992.
Kleinenberg, N.— Invertebrates, 1328-1330.
Kleinwächter, L.— Yolk sac, 3072.
Klever, E — Teeth, 2717.
Klinckowström, A. de.— Epiphysis, 3187.
Knüpffer, W.— Birth, 3108.
Kobelt, G. L.— Urogenital, 2917.
Kober, J.— Mammals, 1503.
Kochs.— Wolffian body, 3055.
Kodis, T.— Epidermis, 620.
Koehler, R.— Spermatozoa, 2617-2618.
Kölliker, A.— Amphibia, 69 — Amphioxus, 90 — Blood, 195 — Bone, 287 — Cerebellum, 464 — Epidermis, 621-622 — Eye, 730-731 — Fat, 774 — General works, 878-881 — Germ layers, 975-979 — Heredity, 1135-1136 — Human embryo, 1183-1184 — Invertebrates, 1331-1332 — Mammals, 1504-1508 — Muscles, 1617-1619 — Nails, 1668-1669 — Nerves, cephalic, 1724 — Nervous tissue, 1754-1755, 3341 — Nose, 1813 — Notochord, 1830-1832 — Pineal gland, 2052 — Placenta, 2167 — Segmentation of ovum, 2333-2335 — Skeleton, 2448 — Skull, 2494 — Spermatozoa, 2619 — Spinal cord, 2657-2659 — Teeth, 2718 — Twins, 2879.
Kölliker, T.— Skull, 2495.
König, K. P.— Placenta, 3395.
Köster.— Umbilical cord, 2882.
Koller, C.— Germ layers, 981-982.
Kollmann, J.— Brain, 341 — Coelom, 473 — Epidermis, 623 — Germ layers, 983-985a — Heredity, 1137-1138 — Human embryo, 1185-1187 — Limbs, 1398 — Myotomes, 1661 — Notochord, 1833 — Primates, 3400-3401 — Skull, 2496 — Teeth, 2719-2720 — Urogenital, 2918-2919 — Vertebrates, 3035-3036.
Kolosson, A.— Spermatogenesis, 2567.
Kolster, R.— Cartilage, 372.
Korotnef, de.— Spermatogenesis, 2568 — Spermatozoa, 2620.
Korschelt.— Invertebrates, 1333.
Kossmann, R.— Notochord, 1834.
Kostanecki, K. v — Blood, 3111 — Cell division, 443 — Liver, 3299.
Koster, W.— Ovary, 1885-1886 — Ovum, 1980.
Koubassoff.— Placenta, 2168.
Kowalevsky, A.— Amphioxus, 91-92 — Invertebrates, 1333a.
Kowalewski, M. von.— Teleosts, 2786-2787.
Kowalewsky, Owsjannikow, *and* Wagner, N.— Ganoids, 829.
Krause, C.— Ovary, 1887.
Krause, R.— Ear, 559.
Krause, W.— Allantois, 9-11 — Human embryo, 1188-1189 — Spermatozoa, 2621-2622.
Kranshaar, R.— Hypophysis, 1216.
Krösing, P.— Muscles, 3328.
Kromayer, E.— Protoplasm, 3402
Krüger, F.— Blood, 196.
Krüger, R.— Foetal membranes, 795.
Krukenberg.— Kidney, 1364.
Krukenburg, G.— Amniotic fluid, 51— Foetal membranes, 796.
Kuborn, P.— Blood, 197.
Kühne, W.— Protoplasm, 2273.
Kükenthal, W.— Blood, 198 — Limbs, 3292 — Skeleton, 3433 — Teeth, 2721, 3469.
Küstner.— Uterus, 2993
Kuhn.— Ear, 557-558.
Kultschitzky, N.— Impregnation, 1261-1262.
Kundrat, Hanns, *and* Engelmann, G. J.— Uterus, 2994.
Kunkel, A.— Gill clefts, 1046.
Kupffer, C. von.— Allantois, 12 — Decidua, 515 — Evolution of man, 670 — Head, 3235-3236 — Impregnation, 1263 — Mammals, 1509 — Marsipobranchs, 1552 — Nerves, cephalic, 1725 — Neurenteric canal, 1775 — Neuron, 1792 — Spleen, 3456 — Teleosts, 2788 — Urogenital, 2920-2921 — Vertebrates, 3037-3038.
Kupffer, C., *and* Benecke, B.— Birds, 135 — Reptiles, 2287.
Kuskow, N.— Connective tissue, 488.
Kyburg, B — Foetal membranes, 797.
Kyburg, W. B.— Human embryo, 1190.
Lachi, P.— Nervous tissue, 1756-1757 — Ovary, 1888 — Skeleton, 2449 — Teratology, 3498.
La Croix, N. J. de.— Lungs and trachea, 1119.
Laguesse, E.— Head kidney, 1095 — Pancreas, 2035, 3375-3376 — Spleen, 2638-2639.
Laguesse, G. J — Mouth, 1592.
Lahousse, E.— Cerebellum, 465 — Ganglia, 821.
Lamb, D. S.— Yolk sac, 3551.
Lameere, A. — Evolution of man, 671 — Ovum, 1981-1982.
Lampert, K.— Notochord, 1835.
Landois, L.— Bone, 288 — Hairs, 1075.
Lang, G.— Birth, 3109.
Langenbacher, L.— Urogenital, 2922.
Langer, C.— Hairs, 1076 — Intestine, 1311 — Mammae, 1442.
Langhans, T.— Decidua, 516 — Foetal membranes, 798 — Placenta, 2169-2171.
Laniot, M.— Pregnancy, 2259.
Lankester, E. R.— Gastrula theory, 838 — General works, 882-883 — Invertebrates, 1334-1337.
Laskovsky.— Stomach, 2671.
Lassigne, J. L.— Meconium, 1569.
Lataste, F.— Amphibia, 70 — Gestation, 1027 — Teeth, 2722.

Laulanié. — Connective tissue, 489 — Ovary, 1889 — Placenta, 2172-2174.
La Valette, St. George de. — Spermatogenesis, 2587 — Spermatozoa, 2633-2635.
Lavdowsky, M. — Ear, 560.
Leboucq, H. — Blood, 199-200 — Blood vessels, 267 — Cartilage, 373 — Limbs, 1399 — Nerves, 1693 — Notochord, 1836.
Lebrun, Hect. — Cell division, 3152.
Leche, W. — Brain, 342 — Mammals, 1510 — Teeth, 3470.
Lee. — Decidua, 517.
Lee, Arthur B. — Spermatogenesis, 2569-2570.
Lee, R. — Placenta, 2175.
Legal, E. — Nose, 1814-1815.
Legay, Ch. G. — Uterus, 2995.
Legge, Fr. — Blood, 201 — Ovary, 1890 — Ovum, 1983.
Legros, *and* Magitot. — Teeth, 2723.
Leichmann, G. — Ovum, 1984.
Lemière, G. — Ovulation, 1925.
Lemoine, G. — Umbilical cord, 2883.
Lenhossék, M. von. — Ganglia, 822-823, 3205 — Jacobson's organ, 3284 — Nervous tissue, 1758-1760, 3342 — Spinal cord, 2660 — Tongue and taste, 3315.
Lepkowski, W. — Teeth, 2724.
Leopold, G. — Decidua, 518 — Mammals, 1511 — Ovary, 1891 — Ovulation, 1926 — Placenta, 2176, — Uterus, 2996.
Lereboullet, A. — Teleosts, 2789-2791.
Leser, E. — Bone, 289.
Leuckart, R. — Elasmobranchs, 590 — General works, 884 — Ovum, 1985 — Wolffian body, 3056.
Leuret, F., *and* Gratiolet, L. P. — Brain, 343.
Levinson, F. — Amniotic fluid, 52.
Leydig, F. — Cells, 407 — Elasmobranchs, 591 — General works, 885 — Hairs, 3231 — Ovum, 1986-1987 — Pineal gland, 2053-2054 — Segmentation of ovum, 2336.
Lieberkühn, N. — Allantois, 13 — Bone, 290-291 — Eye, 732-735 — Kidney, 1365 — Mammals, 1512-1514 — Notochord, 1837-1838 — Pineal gland, 2055 — Placenta, 2177.
Lieberkühn, N., *and* Bermann. — Bone, 292.
Liebermann, L. — Nutrition of embryo, 1859.
Liessner, E. — Gill clefts, 1047.
Lilienfeld, L. — Blood, 202.
Lindes, G. — Heart, 1115.
Lindgren, H. — Ovum, 1988.
List, J. H. — Anus, 99-100 — Blood, 203 — Epidermis, 624 — Teleosts, 2792.
Lockwood, C. B. — Diaphragm, 533 — Mesentery and omentum, 1574 — Testis, 2832.
Locy, W. A. — Neuron, 3349.
Lode, Alois. — Spermatozoa, 2623.
Loeb, Jacques. — Segmentation, 3422.
Löwe, L. — Bone, 293 — Connective tissue, 490 — Evolution of man, 672 — Eye, 736-737 — Foetal membranes, 799 — Impregnation, 1264 — Kidney, 1366 — Neuron, 1793 — Notochord, 1839 — Spinal cord, 2661-2662 — Teeth, 2725 — Urogenital, 2923.
Loewenhardt. — Pregnancy, 2260.
Löwenthal, N. — Ovum, 1989-1991.
Löwenthal, W. — Uterus, 2997.
Löwit, M. — Blood, 204-205.
Lombardini, L. — Placenta, 2178 — Uterus, 2998.
Loudon, B. — Bladder, 143c — Intestine, 1312.
Longet, F. A. — General works, 886.
Lubimoff, A. — Neuron, 1794.
Ludwig, H. — Ovum, 1992.
Lüsebrink, F. W. — Placenta, 2179.
Lustig, A. — Thymus and thyroid, 2847-2848 — Tongue and taste, 2861.
Luzet, Ch. — Blood, 3112.
Luzi, F. — Decidua, 519.
Lwoff, Basilius. — Amphioxus, 3090-3091 — Connective tissue, 491 — Germ layers, 3220 — Notochord, 1840-1841.
Macalister, A. — Vertebrae, 3540.
Macallum, A. B — Blood, 206 — Cells, 408 — Nuclei, 3356.
Macbride, E. W. — Urogenital, 2924.
McClure, C. F. W. — Neuron, 1795.
McCrady. — Heredity, 1139.
Macdonald, W. — Blood vessels, 3127.
Macewen, W. — Bone, 294.
McIntosh. — Teleosts, 3489.
McIntosh, W. C., *and* Prince, E. E. — Teleosts, 2793.
McKay, W. J. — Pineal gland, 2056.
McKendrick, J. G. — Heredity, 1140.
Mackness, G. O. — Growth, 1062.
McMurrich, J. P. — Muscles, 1627 — Teleosts, 2794.
McNeil, J. — Evolution of man, 673.
Maggi, L. — Leucocytes, 1378a.
Maggiorani, C. — Ovum, 1993.
Magini, G. — Nervous tissue, 1761.
Magitot, E. — Teeth, 2726.
Magitot, E., *and* Legros, Ch. — Teeth, 2727-2728.
Majewski, A. — Amnion, 34.
Makay, J. Yule. — Blood vessels, 268.
Malassez, L — Blood, 207 — Teeth, 2730.
Mall, F. — Coelom, 474 — Connective tissue, 492-493 — Ear, 561 — Gill clefts, 1048 — Human embryo, 1191 — Intestine, 3281 — Liver, 3300 — Retina, 3413 — Thymus and thyroid, 2849.
Malm, R. — Teeth, 2729.
Mangin, L. — Cells, 409.
Mann, G. — Cell theory, 3159.
Manz. — Eye, 738.
Marcacci, A. — General works, 887.
Marchand, F. — Brain, 344.
Marey, H. O — Placenta, 2180.
Margo, T. — Muscles, 1620.
Marion, A. F. — Teleosts, 2795.
Mark, E. L. — Ganoids, 830 — Impregnation, 1265.
Marotta, A. — Amnion, 3083.
Marshall, A. M. — Nerves, 1694 — Nerves, cephalic, 1726-1729 — Nose, 1816 — Testis, 3506.
Marshall, A. M., *and* Bles, Ed. J. — Blood vessels, 269 — Head kidney, 1096.
Marshall, C. F. — Muscle, 1621-1622.
Marshall, J. — Veins, 3025.

Martin, E.— Wolffian body, 3057.
Martin, P.— Eye, 739 — Genitalia external, 933 — Nerves, cephalic, 1730-1732 — Stomach, 2672-2673.
Martini, V.— Skull, 2497.
Masius, J.— Heart, 1116 — Nervous tissue, 3343 — Placenta, 2181.
Masquelin, H.— Skull, 2498.
Masquelin, H., *and* Swaen, A.— Placenta, 2182.
Massart, J.— Impregnation, 1266.
Maupas, E.— Sexuality, 2393.
Maurer, F.— Connective tissue, 3166 — Gills, 1028 — Hairs, 3232 — Muscles, 1623 — Spleen, 2640 — Thymus and thyroid, 2850-2851.
Mauthner, J.— Placenta, 2183.
Mayeda, R.— Muscles, 1624.
Mayer, P.— Heart, 1117.
Mayer, S.— Muscles, 1625-1626 — Oesophagus, 1860 — Thymus and thyroid, 2852.
Mayor, A.— Uterus, 2999.
Mayrhofer — Ovary, 1892 — Ovulation, 1927.
Mazzoni, V.— Nervous tissue, 3344.
Meckel, H. v.— Ovary, 1893.
Meckel, J. F.— Brain, 345 — General works, 888 — Mesentery and omentum, 1575.
Mehnert, E.— Reptiles, 3405 — Skeleton, 2450-2452.
Meigs, C. D.— Mammals, 1515.
Meissels, A. W.— Blood, 208.
Melland, B.— Muscles, 1628.
Menden, J.— Bone, 295.
Meola, F.— Foetal membranes, 800 — Uterus, 3000.
Merk, L.— Nervous tissue, 1762-1763.
Merkel, F.— Spermatogenesis, 2571-2572.
Merkel, F., *and* Orr, A. W.— Eye, 3197.
Mertsching.— Epidermis, 625.
Metschnikoff, E.— Gastrula theory, 839-840 — Invertebrates, 1338.
Meuron, P. de.— Oesophagus, 1861 — Thymus and thyroid, 2853.
Meves, Fr.— Cell division, 444.
Meyer, E.— Segmentation of body, 2315.
Meyer, H.— Eye, 3198 — Ovary, 1894 — Wolffian body, 3058.
Meyer, L.— Placenta, 2184.
Meyer, P. J.— Pregnancy, 2261.
Meyerson, S.— Epidermis, 626.
Miescher, F. — Segmentation of ovum, 2337 — Spermatogenesis, 2573.
Mihalkowics, V. von.—Brain, 346 — Eye, 740 — Hypophysis, 1217-1218 — Notochord, 1842 — Pineal gland, 2057 — Testis, 2833 — Urogenital, 2925.
Miklucho, M. N.— Nerves, 1695.
Miles, M.— Heredity, 3251.
Miller, W. S.— Lungs and trachea, 1420.
Milne-Edwards, A.— Foetal membranes, 801-802 — See Edwards, A. M.
Mingazzini, G.— Brain, 347, 3141-3142.
Mingazzini, P.— Muscles, 1629.
Minot, C. S.— Blood, 209 — Brain, 3143 — Decidua, 520 — Epidermis, 627 — Evolution of man, 674 — Foetal membranes, 803 — Germ layers, 986 — Growth, 1063-1064 — Heredity, 1141 — Placenta, 2185-2187 — Segmentation of ovum, 2338 — Sexuality, 2394.
Mitsukuri, K.— Foetal membranes, 804 — Germ layers, 987-988, 3221 — Reptiles, 3406-3407 — Supra-renals, 2686 — Wolffian body, 3059.
Mitsukuri, K., *and* Ischikawa, C.— Germ layers, 989 — Reptiles, 2288.
Mivart, St. G.— Evolution of man, 675 — Limbs, 1400.
Mix, C. L.— Blood, 3113.
Mochnatscheff.— Placenta, 2188.
Möbius, K.— Hairs, 3233.
Möricke.— Decidua, 521.
Mogilowa, Anna R.— Placenta, 2189.
Moldenhauer, W.— Ear, 562-563.
Moleschott, J.— Birds, 136.
Mollier, S.— Head kidney, 1097 — Limbs, 3293.
Mondino, C.— Blood, 210-211.
Mondino, C., *and* Sala, L.— Blood, 212 — Impregnation, 1267.
Montgomery, E.— Cells, 410.
Moquin-Tandon, A.— Amphibia, 71.
Morawski, F.— Placenta, 2190.
Morgan, T. H.— Amphibia, 3087 — Blastopore, 150 — Mammals, 3305— Metamerism, 3321 — Ovum, 1994.
Morpurgo, B — Aorta, 108 — Blood vessels, 270.
Morpurgo, B., *and* Tirella, V.— Ganglia, 3206.
Morrison, R. B.— Epidermis, 628.
Morse, E. S — Evolution of man, 676.
Moser, E.— Synovia, 2697.
Mosso, A.— Blood, 213 215.
Müller, A.— Impregnation, 1268 — Marsipobranchs, 1553 — Skeleton, 2453.
Müller, E.— Blood, 216.
Müller, H. F.— Blood, 217— Bone, 297— Eye, 3199-3200— Notochord, 1843 — Uterus, 3001.
Müller, J.— General works, 889— Glands, 1056 — Human embryo, 1192-1193— Marsipobranchs, 1554 — Mesentery and omentum, 1576 — Ovum 1995 — Urogenital, 2926.
Müller, V.— Urogenital, 2927.
Müller, W.— Eye, 741— Hypophysis, 1219-1220 — Lungs and trachea, 1420 — Notochord, 1844-1845 — Thymus and thyroid, 2854-2855 — Urogenital, 2928.
Mummery, J. H.— Teeth, 3471.
Nägeli.— Heredity, 1142.
Nagel, W.— Allantois, 14 — Amnion, 35— Limbs, 1401 — Ovary, 1895-1898 — Ovum, 1996— Urogenital, 2929-2932, 3522— Uterus, 3002-3003.
Nahm, G.— Amniotic fluid, 53.
Nakagawa, I.— Brain, 348.
Narath, A.— Lung, 3302.
Nasse, O.— Foetal membranes, 805.
Nathusius.— Ovum, 1997.
Navalichini.— Muscles, 1630.
Nelson, E. M.— Spermatozoa, 2624.
Nesbitt, R.— Skeleton, 2454.
Nestler, K.— Marsipobranchs, 1555.
Neugebauer, L. A.— Umbilical cord, 2884.
Neumann, E.—Blood, 218-219—Oesophagus, 1862— Spermatogenesis, 2574.
Newport.— Impregnation, 1269.
Nicolaides, K.— Blood, 220.
Nicolas, A.— Cell division, 3153 — Spermatogenesis, 3446 — Urogenital, 2933 — Wolffian body, 3548.

Niessing, G.— Spermatogenesis, 2575.
Nijhoff, G. C.— Impregnation, 1270.
Nitabuch, R — Placenta, 2192.
Noorden, C. v.— Ear, 564.
Noorden, W. von.— Skull, 2499.
Norris, H. W.— Ear, 3175 — Head, 1082.
Nuel, J.— Ear, 565.
Nuel, J. T. — Eye, 742.
Nuel, P. J.— Marsipobranchs, 1556.
Nusbaum, J.— Blood, 3114 — Placenta, 2193.
Nussbaum, M.— Cell division, 445— Growth, 1065-1067 — Heredity, 1143, 3252— Notochord, 1846-1847 — Ovum, 1998 — Sexuality, 2395.
Obrastzow.— Blood, 221.
Oellacher, J.— Heart, 1118 — Ovum, 1999-2000 — Pericardium, 2038— Segmentation of ovum, 2339— Teleosts, 2796-2798.
Ognew, J.— Connective tissue, 494.
Oldfield, T.— Teeth, 3472.
Oliver, J.— Decidua, 522.
Olivetti, M.— Allantois, 15.
Olt, Ad.— Teleosts, 3490.
Onodi, A. D.—Nerves, cephalic, 1733—Sympathetic, 2692.
Opitz, W.— Amnion, 36 — Oesophagus, 1863.
Oppel, A — General works, 3209— Impregnation, 1271, 1272 — Myotomes, 1662.
Orr, Henry.— Amphibia, 72 — Reptiles, 2289.
Orth, J.— Placenta, 2194.
Osborn, H. F.— Brain, 349-353— Evolution of man, 677, 3189 — Foetal membranes, 806-808 — Heredity, 1144, 3253-3254 — Teeth, 2731, 3473-3474.
Osler, W.— Blood vessels, 271.
Ostroumoff, A.— Blastopore, 151 — Reptiles, 2290.
Overlach, M.— Decidua, 523.
Owen, R.— Foetal membranes, 809-810 — General works, 890 — Mammals, 1516-1519 — Ovum, 2001 — Pineal gland, 2058— Teeth, 2732-2733.
Owsjannikow.—Marsipobranchs, 1557-1558— Pineal gland, 2059— Segmentation of ovum, 2340 — Teleosts, 2799.
Packard, A. S.— Evolution of man, 678-679.
Paladino, G.— Mammals, 1520-1521, 3306 — Ovary, 1899-1900 — Ovum, 2002.
Paneth, J.— Intestine, 3282— Muscles, 1631-1632.
Pansini, S.— Connective tissue, 495.
Parker, R. W., *and* Robinson, H. B.— Limbs, 1402.
Parker, T. J.— Birds, 3106— Elasmobranchs, 592 — Skeleton, 2455 — Uterus, 3004.
Parker, W. H.— Reptiles, 2291.
Parker, W. K.— Evolution of man, 680-681— Face, 764— Skeleton, 2456-2458 — Skull, 2500-2526.
Parker, W. K., *and* Bettany, G. T.— Skull, 2527.
Paschen, D.— Uterus, 3005.
Patenko, T.— Uterus, 3006.
Paterson, A. M.—Limbs, 1403— Myotomes, 1663—Nerves, 1696-1697 — Sympathetic, 2693.
Patten, Wm.— Evolution of man, 682 — Invertebrates, 1339.
Patzelt, V.— Intestine, 1313.
Paulisch, O.— Notochord, 1848.
Peaslee, E. R.— Blood, 222.
Peremeschko.— Blood, 223-224 — Germ layers, 990 — Spleen, 2641-2642.
Perényi, Josef.— Amnion, 37 — Germ layers, 991, 3222 — Neurenteric canal, 1776 — Notochord, 1849 — Reptiles, 2292-2293 — Wolffian body, 3060.
Perugia, A.— Elasmobranchs, 593.
Pestalozza, E.— Uterus, 3525.
Petersen, H.— Skeleton, 3434.
Petitpierre, L.— Ovum, 2003.
Pflüger.— Decidua, 524.
Pflüger, E.— Hybrids, 1213 — Impregnation, 1273 — Mammals, 1522 — Ovary, 1901 — Segmentation of ovum, 2341-2343 — Sex, 2372-2373.
Philip, R. W.— Lungs and trachea, 1421.
Phisalix, C.— Human embryo, 1194-1196 — Nerves, cephalic, 1734 — Spleen, 2643 — Veins, 3026.
Picchini, L.— Aorta, 3098.
Piersol, G. A.— Epidermis, 629 — Gill clefts, 1049 — Spermatozoa, 2625, 3453.
Pilliet, A.— Stomach, 2674 — Supra-renals, 3462.
Pinko, K.— Amniotic fluid, 54.
Planteau, H.— Skeleton, 2459.
Platner, E. A.— Blood vessels, 272.
Platner, G.— Cell division, 446-447—Cells, 411-413— Impregnation, 1274 — Ovum, 2004 — Segmentation of ovum, 2344 — Spermatogenesis, 2576.
Platt, Julia B — Head, 1083-1084 — Notochord, 1850 — Segmentation of body, 2316 — Skull, 3440.
Ploetz, A. J.— Spermatozoa, 2626.
Pohlmann, J.— Teeth, 2734.
Poljakoff, P.— Fat, 775.
Pollard, H. B.— Lateral line, 3289.
Pott, E.— Sex, 2374.
Pouchet, G.— Blood, 225 — Mammals, 1523 — Teleosts, 2800— Urogenital, 2931.
Pouchet, G., *and* Chabry.— Teeth, 2735.
Pouchet, *and* Tourneux.— Nerves, 1698.
Prenant, A.— Archenteron, 120 — Cell division, 448, 3154 — Cells, 414 — General works, 891 — Placenta, 2195— Spermatogenesis, 2577-2578, 3447 — Spermatozoa, 2627-2628 — Testis, 2834-2835.
Preobaschensky, S.— Nose, 3352.
Prenschen, F. von.— Allantois, 16 — Human embryo, 1197.
Prévost, *and* Dumas.— Mammals, 1524 — Segmentation of ovum, 2345.
Prévost, *and* Lebert.— Blood, 226-229.
Prince, E. E — Limbs, 1404 — Teleosts, 2801-2802.
Pritchard, U.— Ear, 566.
Prochownick, L.— Amniotic fluid, 55.
Purkinje, J. E.— Ovum, 2005.
Putelli, F.— Larynx, 1376 — Nose, 1817.
Pyle, J P.— Placenta, 2196.
Rabattel, R.— Eye, 743.
Rabl, C.— Cell division, 449-450 — Cells, 415-417 — Cervical sinus, 467 — Germ layers, 992-993, 3223 — Heart, 1119 — Invertebrates, 1340-1342 — Nerves, cephalic, 1735 — Segmentation of body, 2317.
Rabl, H.— Supra-renals, 2687.
Rabl-Rückhard, H. — Brain, 354 — Cartilage, 374 — Notochord, 1851 — Pineal gland, 2060.

Radwaner.— Eye, 744.
Raffaele, F. A.— Blood vessels, 3128.
Ramon y Cajal.— *See* Cajal.
Ramsay, E. P.— Ovum, 2006.
Ransom, W. H.— Impregnation, 1275 — Teleosts, 2803.
Ranvier, L.— Blood, 230 — Blood vessels, 273 — Bone, 298 — Epidermis, 630 — Mesentery and omentum, 1577 — Nerves, 1699-1701 — Tendon, 2822.
Rath, O. von.— Spermatogenesis, 3448.
Rathke, H.— Aorta, 109-110 — General works, 892-895 — Gill clefts, 1050 — Hypophysis, 1221 — Lungs and trachea, 1422 — Reptiles, 2294-2295, 3408 — Skeleton, 2460-2461 — Skull, 2528 — Urogenital, 2935-2936 — Veins, 3027-3028, 3528.
Rauber, A.— Allantois, 17 — Birds, 137 — Blastopore, 152-153 — Cells, 418 — Germ layers, 994-999 — Mammae, 1443 — Mammals, 1525 — Nervous tissue, 1764 — Ovum, 2007.
Rauber, A., *and* Moldenhauer, W.— Ear, 567.
Randnitz, R. W.— Connective tissue, 496.
Ravn, E.— Diaphragm, 534-538 — Foetal membranes, 811 — Proamnion, 2266.
Ravogli, A.— Dermis, 530.
Rawitz, B.— Ganglia, 824.
Real y Beyro, M.— Eye, 745.
Regnauld, E.— Urogenital, 2937, 3523.
Reichel, P.— Mouth, 1593 — Urogenital, 2938.
Reichenbach, H.— Invertebrates, 1343.
Reichert, K. B.— General works, 898-899 — Gill clefts, 1051 — Head, 1085 — Human embryo, 1198 — Mammals, 1526-1527 — Micropyle, 1586 — Notochord, 1852 — Segmentation of ovum, 2346-2347 — Skull, 2529 — Teeth, 2736 — Urogenital, 2939.
Reid.— Placenta, 2197.
Rein, G.— Impregnation, 1276 — Mammae, 1444-1445.
Reinhard, W.— Teleosts, 2804.
Reinke, F.— Epidermis, 631.
Reissner, E.— Ear, 3176.
Reitz.— Placenta, 2198-2199.
Remak, H.— Germ layers, 3224.
Remak, R.— Blood, 231 — General works, 896-897.
Remmett, A. A.— Uterus, 3007.
Remy, C.— Epidermis, 633 — Human embryo, 1199.
Renaut, J.— Cartilage, 375 — Epidermis, 632 — Umbilical cord, 2885.
Renson, G.—Spermatogenesis, 2579—Wolffian body, 3061.
Repiachoff.— Germ layers, 1000-1001.
Repiachoff, W.— Mammals, 1528.
Retterer, E.— Anus, 101-102 — Connective tissue, 3167 — Epidermis, 634 — Genitalia external, 3213-3214 — Intestine, 1314 — Mammals, 3307 — Thymus and thyroid, 2856 — Tonsil, 2866 — Urogenital, 2940-2941, 3524.
Retterer, E. *and* Robin, Ch — Blood vessels, 274.
Retzius, A.— Brain, 355.
Retzius, G.— Bone, 299 — Cerebellum, 3162 — Ear, 568, 3177 — Eye, 746 — Hemispheres, 3241-3242 — Liver, 3301 — Muscles, 1633 — Nerves, 1702 — Nerves, cephalic, 3337 — Nervous tissue, 3345 — Neuroglia, 3347 — Notochord, 3353 — Ovary, 1902 — Spermatozoa, 2629.
Reubold, W.— Brain, 356.
Rex, H.— Veins, 3029, 3529.
Ribbert.— Mammae, 1446.
Ribemont, D. A.— Placenta, 2200.
Richarz, T.— Heredity, 1145 — Sex, 2375.
Richiardi, S.— Eye, 747.
Riedel, B.— Kidney, 1367.
Rieke, A.— Eye, 748.
Rieneck.— Teleosts, 2805.
Riess, J. A.— Germ layers, 1002.
Rindfleisch, E.— Blood, 232-233.
Ritter, W. E.— Pineal gland, 2061.
Ritzen, F. A.— Placenta, 2201.
Robertson, W. G. A.— Teeth, 3475.
Robin, Ch.— Blood, 234 — Invertebrates, 1344 — Notochord, 1853 — Placenta, 2202-2203 — Skeleton, 2462.
Robin, H. A.— Foetal membranes, 812.
Robinson, A.— Lungs and trachea, 1423 — Mammals, 1529 — Spinal cord, 2663 — Veins, 3030 — Yolk-sac, 3073.
Robinson, A., *and* Assheton, R.— Germ layers, 1003.
Römer, F.— Epidermis, 3185 — Mammals, 3308.
Röse, C.— Heart, 1120-1121 — Jacobson's organ, 3285 — Teeth, 2737-2739, 3476-3485.
Roetter, F.— Teeth, 2740.
Rogie.— Yolk sac, 3552.
Rohr, K.— Placenta, 2204.
Rolleston.— Placenta, 2205.
Rollett, A.— Connective tissue, 497 — Muscles, 1634-1635.
Romiti, G.— Blood, 235 — Decidua, 525-526 — General works, 900-902 — Germ layers, 1004-1005 — Human embryo, 1200 — Notochord, 1854 — Placenta, 2206-2208 — Spermatozoa, 2630 — Spinal cord, 2664 — Urogenital, 2942 — Uterus, 3008-3009.
Rosculhetz, V.— Genitalia external, 934.
Rosenberg, A.— Limbs, 1405.
Rosenberg, E.— Skeleton, 2463 — Skull, 2530.
Rosenmüller, J. C.— Urogenital, 2943.
Rossi, U.— Spermatozoa, 2631.
Roth, M.— Urogenital, 2944 — Wolffian body, 3062.
Roth, W.— Larynx, 1377.
Rouget.— Ovulation, 1928.
Rouget, Ch.— Blood vessels, 275-276 — Bone, 300 — Nerves, 1703-1704 — Ovary, 1903 — Urogenital, 2945.
Roule, L.— Muscles, 1636.
Rouvier, J.— Decidua, 527.
Roux, W.— General works, 903, 3210 — Neuron, 1796 — Segmentation, 3423 — Segmentation of ovum, 2348-2351a.
Rudolph, K. A.— Mammals, 1530.
Rückert, Joh.— Germ layers, 1006-1007 — Gill clefts, 1052 — Impregnation, 1277-1279 — Ovum, 2008, 3371 — Urogenital, 2946-2947.
Rüdinger, N.— Ear, 569-570 — Intestine, 1315.
Ruge, C.— Foetal membranes, 813 — Placenta, 2209 — Umbilical cord, 2886-2887.
Ruge, G.— Coelom, 3163 — Muscles, 1638-1639 — Ovary, 1904 — Skeleton, 2464-2465 — Vertebrae, 3541.
Rusconi.— Impregnation, 1280 — Teleosts, 2806.
Ryder, J. A.— Amnion, 38 — Epidermis, 635 — Evolution of man, 683, 3190 —Ganoids, 831-832 — General works, 904 — Germ layers, 1009 — Hairs, 1077 — Limbs, 1406

Ryder, J. A.
— Mammae, 1447 — Mammals, 1531 — Ovum, 3372 — Placenta, 2210-2212 — Segmentation of ovum, 2352-2353 — Sex, 2376 — Teleosts, 2807-2817 — Yolk sac, 3074.
Sabatier, A.—General works, 3211 — Limbs, 1407 — Ovum, 2009-2010 — Sex, 2377 — Sexuality, 2396-2400 — Spermatogenesis, 2580-2581, 3449.
Sabine.—Umbilical cord, 2888.
Sacchi, Maria.— Amphibia, 73.
Saexinger, J. von.— Pregnancy, 2262
Sagemehl, M.— Nerves, 1705.
Sala, L.— Brain, 357 — Sympathetic, 3465.
Salensky, W.— Ear, 571 — Evolution of man, 684 — Ganoids, 833-835 — General works, 905 — Tunicates, 2873.
Salvioli, I.— Connective tissue, 498 — Stomach, 2675-2676 — Urogenital, 2948.
Samassa, P.— Germ layers, 3225.
Sandmeyer, W.— Amniotic fluid, 56.
Sanfelice, F.— Blood, 236, 3115 — Spermatogenesis, 2582.
Sarasin, C. F.— Segmentation of ovum, 2354.
Sarasin, P.— Germ layers, 1010.
Scanzoni.— Mammae, 1448.
Schäfer, E. A.— Blood, 237 — Bone, 301 — Mammals, 1532 — 1534 — Muscles, 1640-1641 — Nervous tissue, 3346 — Protoplasm, 2274.
Schäffer, J.— Bone, 302 — Testis, 3502.
Schaeffer, O.— Ear, 3178 — Ear, external, 3179 — Growth, 3230 — Skull, 3441.
Schanz, F.— Neurenteric canal, 1777.
Schaper, A.— Retina, 3414.
Schapringer, A.— Neuron, 1797.
Scharff, R.— Evolution of man, 685.
Schatz, F.— Placenta, 2213-2215 — Twins, 2880.
Scheel, C.— Vertebrae, 3542.
Schenk.— Impregnation, 1281.
Schenk, S. L.— Amnion, 39 — Ear, 572 — Eye, 749 — General works, 906 — Germ layers, 1011-1014 — Gills, 1029 — Heart, 1122-1123 — Pancreas, 2036.
Schenk, S. — Yolk sac, 3075.
Schenk, S., *and* Birdsall, W.— Sympathetic, 2694.
Scherenziss, D.— Blood, 238.
Scheviakoff, W.— Cell division, 453.
Schimkewitsch, W.— Evolution of man, 686 — Heart, 1124.
Schlechter, J.— Sex, 2378.
Schleicher, W.— Cartilage, 376 — Human embryo, 1201.
Schlosser, Max v.— Evolution of man, 687.
Schmidt, F.— Brain, 358 — Heart, 1125.
Schmidt, H. D — Blood, 239 — Blood vessels, 278 — Nervous tissue, 1765.
Schmidt, M. B.— Blood, 3116.
Schmidt, V.— Notochord, 3354.
Schmiegelow, E.— Testis, 2836.
Schneider, A.— General works, 907 — Impregnation, 1282-1285 — Muscles, 1642-1643 — Vertebrates, 3039.
Schöbl, J.— Fat, 776.
Schoeler, H.— Eye, 750.
Schönemann, A.— Hypophysis, 3261.
Schöney, L — Bone, 303.
Schoof, F.— Urogenital, 2949.
Schott, J. A. G.— Umbilical cord, 2889.
Schottlaender, J.— Ovary, 1905, 3360.
Schröder, K.— General works, 908 — Intestine, 1316.
Schroeder van der Kolk, J. L. C.— Placenta, 2216.
Schrön, O.— Ovary, 1906.
Schütz, J.— Ovum, 2011.
Schulin, K.— Bone, 304 — Ovary, 1907 — Skeleton, 2466.
Schultz, A.— Elasmobranchs, 594-595.
Schultze, B. S.— Placenta, 2217 — Umbilical cord, 2890-2891 — Yolk sac, 3076.
Schultze, F. E.— Muscles, 1645.
Schultze, M.— Amphioxus, 3092 — Eye, 751-752 — Marsipobranchs, 1559 — Muscles, 1644 — Protoplasm, 2275 — Segmentation of ovum, 2355.
Schultze, O.— Amphibia, 74— Cell division, 454 — Cells, 419 — Eye, 753 — Germ layers, 1015 — Impregnation, 1286-1287 — Mammae, 1449, 3303 — Neuron, 1798 — Segmentation, 3424 — Segmentation of ovum, 2356.
Schwabach.— Tonsil, 2867.
Schwabe, C. G.— Human embryo, 1202.
Schwabe, G.— Human embryo, 1203.
Schwalbe, G.— Nerves, cephalic, 1736.
Schwalbe, G.— Brain, 359 — Ear, 573-575 — Ganglia, 825 — General works, 909-910.
Schwarck, W.— Skeleton, 2467.
Schwarz, D.— Germ layers, 1016.
Schwarz, E.— Cell division, 455.
Schwarz, F.— Protoplasm, 2276.
Schwegel, A.— Skeleton, 2468.
Schweigger-Seidel, F.— Genitalia external, 935 — Kidney, 1368 — Spermatogenesis, 2583.
Schwink, F.— Blood, 240 — Germ layers, 1017 — Heart, 1126 — Skull, 2531.
Sclavunos, G. L.— Stomach, 2677.
Scott, W. B.—Evolution of man, 688 — Hypophysis, 1222 — Marsipobranchs, 1560-1562.
Scott, W. B., *and* Osborn, H. F. — Amphibia, 75.
Sedgwick, A.— Elasmobranchs, 3180 — Invertebrates, 1345-1347 — Kidney, 1369 — Neuron, 1779 — Segmentation of body, 2318 — Urogenital, 2950 — Wolffian body, 3063.
Seessel, A.— Pharynx, 2039.
Sehlen, D. von.— Micropyle, 1587.
Seiler, D., *and* Burchard, W.— Human embryo, 1204.
Seiler, H.— Eye, 754.
Selenka, E.— Brain, 360 — General works, 911-916 — Germ layers, 1018 — Impregnation, 1288 — Invertebrates, 1348 — Lungs and trachea, 1424 — Mammals, 1535-1536, 3309 — Oesophagus, 1864 — Placenta, 2218.
Semmer, A.— Skull, 2532.
Semon, R.— Urogenital, 2951-2952 — Wolffian body, 3064.
Semper, C.— General works, 917-918 — Urogenital, 2953.
Senator.— Meconium, 1570.
Sernoff, D.— Urogenital, 2954.
Serres.— Birds, 138.
Sertoli, E.— Lymphatics, 1433 — Spermatogenesis, 2584-2585.
Sewall, Henry.— Stomach, 2678.
Sewertzoff, A. N.— Metamerism, 3322.
Sewertzon, A. N.— Skull, 2533.

Seydel, Otto.— Nose, 1818.
Sharp, B.— Eye, 755.
Shaw, J.— Brain, 361.
Sheldon, Lilian.— Invertebrates, 1349 — Ovum, 2012.
Shipley, A. E.— Marsipobranchs, 1563.
Shore, T. W.— Evolution of man, 689 — Liver, 1415.
Shore, T. W., *and* Pickering, J. W.— Proamnion, 2267.
Short, J. L.— Sex, 3427.
Sidebotham, H.— Neurenteric canal, 1778.
Siebenmann, F.— Ear, 576.
Sihler, Ch.— Teeth, 2741.
Simon, J. F.— Meconium, 1571.
Simpson, J. Y.— Umbilical cord, 2892.
Sinéty, de — Mammae, 1450 — Uterus, 3010-3011.
Slavjansky, K.— Ovary, 1908-1909.
Smiechowski, A — Germ layers, 3226.
Smith, F.— Gastrula theory, 841.
Sobotta, J.— Uterus, 3012.
Soemmerring, S. T.— Human embryo, 1205.
Solger, B.— Cartilage, 377-378 — Cell division, 451-452 — Coelom, 475 — Ovum, 2013.
Spee, F. Graf v. — Archenteron, 119 — Decidua, 3169— Human embryo, 1206-1206a — Mammals, 1537a — Teeth, 2742 — Wolffian body, 3065.
Spencer, W. B.— Amphibia, 76-77 —Blood vessels, 3129 — Pineal gland, 2062 — Teratology, 3499.
Spengel, J. W.— Evolution of man, 690 — Invertebrates, 1350 — Urogenital, 2955.
Spiegelberg, O.— Ovary, 1910-1911.
Spina.—Cartilage, 379.
Spöndli, H.— Skull, 2534.
Spronk, C. H. H.— Cartilage, 380.
Spuler, A — Blood, 3117.
Staderini, R.—Ear, 577.
Staehly, A — Ganglia, 826.
Stassano.—Spermatozoa, 2632.
Staurenghi, C.— Yolk sac, 3553.
Steinhaus, J.— Ovulation, 1929.
Stieda, L — Lungs and trachea, 1425 — Thymus and thyroid, 2857.
Stirling, Wm.— Muscles, 1646.
Stöhr, Ph — Pancreas, 3377 — Skull, 2535-2537 — Tonsil, 2868-2869.
Stoss.— Intestine, 1317 — Pancreas, 2037.
Stoss, A.— Intestine, 3283.
Strahl, H.— Allantois, 18-20 — Blood, 241-242 — Germ layers, 1019 — Intestine, 1318 — Mammals, 1538-1541 — Neurenteric canal, 1779-1782 — Notochord, 1855 — Oesophagus, 1865 — Ovary, 3361 — Ovum, 2014 — Placenta, 2219-2228 — Reptiles, 2296-2304 — Wolffian body, 3066 — Yolk sac, 3077-3078.
Strahl, H., *and* Carius, F.— Heart, 1127.
Strahl, H., *and* Martin, E —Pineal gland, 2063.
Strasburger, E.— Cells, 420.
Strasser, H.— Limbs, 1408 — Skeleton, 2469.
Strawniski, N. — Blood vessels, 277.
Strazza, G.— Larynx, 1378.
Streckeisen, A.— Thymus and thyroid, 2858.
Strelzoff, Z. Z.— Bone, 305.
Stricht, O. van der.— Blood, 243-244, 3118-3120 — Bone, 306 — Cartilage, 381-382 — Germ layers, 3227.
Stricker, S.— Amphibia, 78-80 — Connective tissue, 499 — Germ layers, 1020 — Ovum, 2015.
Strong, O.— Nerves, cephalic, 3338.
Stuhlman, F.—Ovary, 1912 — Ovum, 2016.
Stutz, G.— Umbilical cord, 2893.
Suchannek, H.— Bladder, 143d.
Suddith, W. X.— Bone, 307.
Sutton, J. B.— Brain, 362 — Decidua, 528 — Evolution of man, 691 — Pregnancy, 2263 — Skeleton, 2470.
Swaen, A.— Elasmobranchs, 596.
Swaen, A., *and* Masquelin, H.— Spermatogenesis, 2586.
Swirski, G.— Skeleton, 2471.
Sym, A. C.— Placenta, 2230.
Symington, J.— Brain, 3144.
Tafani, A.— Impregnation, 1289 — Mammals, 1542, 3310 — Placenta, 2231-2233.
Tait, Lawson.—Menstruation, 1582—Umbilical cord, 2894.
Takahasi, S.— Bladder, 143e.
Talbot, E. S — Teeth, 3486.
Tangl, F.— Cell division, 456.
Tanja, T.— Coelom, 3164.
Taschenberg, O.— Parthenogenesis, 3378.
Thacher, J. K.— Limbs, 1409.
Thanhoffer, L.— Spinal cord, 2665.
Thayssen, A.— Kidney, 1370.
Thiersch.— Urogenital, 2956.
Thomas, O — Teeth, 2743.
Thompson, W. D'Arcy.— Limbs, 1410.
Thomson, Allen.— Blood, 245-246 — Human embryo, 1207 — Ovum, 2017.
Thomson, Arthur.—Ovary, 1913.
Thomson, J. A.— Heredity, 1146.
Tiedemann, Fr.— Brain, 363.
Tietze, Alex.— Blood, 247.
Tillmanns, H.— Joints, 1358.
Todaro, F.— Eye, 756 — Reptiles, 3409.
Toepfer, K.— Stomach, 3459.
Toerngren, A.— Amnion, 40.
Török, A. v.— Amphibia, 81-82 — Ovum, 2018.
Toldt, C.— Human embryo, 1208 — Kidney, 1371 — Mesentery and omentum, 1578-1579 — Stomach, 2679.
Toldt, C., *and* Zuckerkandl, E.— Liver, 1416.
Tomes, C. S — Teeth, 2744-2750.
Tonge, M.— Aorta, 111.
Tornier, G — Limbs, 1411 — Skeleton, 2472.
Toupet, *and* Ségall.— Blood, 3121.
Tourneux, F.— Anus, 103-106, 3096 — Genitalia external, 936-937 — Intestine, 1319 — Segmentation, 3425 — Spinal cord, 3457 — Urogenital, 2957-2959 — Yolk sac, 3079.
Tourneux, F., *and* Hermann, G.— General works, 919 — Ovum, 2019 — Spinal cord, 2667 — Thymus and thyroid, 3511.
Tourneux, F., *and* Legay, C. H.— Uterus, 3013.
Tredern, L. S. G. von — Birds, 3107.
Trinchese, S.— Muscles, 1647 — Nerves, 1706.
Tuckermann, F.— Tongue and taste, 2862-2865.
Türstig, J.— Aorta, 112-114.
Turner, Wm.— Brain, 364 — Cells, 421 — Foetal membranes, 814-816 — Mammals, 1543 — Placenta, 2234-2249.

Tuttle, A. H.— Ear, 578.
Underhill.— Uterus, 3014.
Unger, L.— Neuron, 1800.
Unna, P.— Epidermis, 636-637.
Urbantschitsch, V.— Ear, 579-581.
Uskoff, N.— Cell division, 457.
Uskow, N.— Blood, 248 — Diaphragm, 539 — Lungs and trachea, 1426.
Valenti, G.— General works, 920-921 — Hemispheres, 3243 — Human embryo, 3260 — Meninges, 1573 — Nervous tissue, 1766 — Ovary, 1914 — Supra-renals, 2688.
Valenti, G., *and* D'Abundo, G.— Blood vessels, 3130.
Vanhersecke, G.— Hemispheres, 3244.
Varnier, N. H.— Uterus, 3015.
Vassaux.— Eye, 757.
Vay, F.— Segmentation, 3426.
Veit, J.— Ovulation, 3365.
Vejdovsky, Frz.— Ovum, 2020 — Segmental organs, 3416.
Velpeau, A. A. L. M.— General works, 922.
Verson, E.— Cell division, 458 — Spermatogenesis, 2588.
Verworn, M.— Cells, 422.
Vialleton, L.— Aorta, 115, 3099 — Blood vessels, 3131 — Urogenital, 2960.
Vieron, D. M. M.— Kidney, 1372.
Vignal, W.—Nervous tissue, 1767-1772—Spinal cord, 2668.
Villy, Fr.— Ear, 582.
Virchow, H.— Eye, 3201 — Gill clefts, 1053-1054, 3229 — Ovary, 1915 — Ovum, 2021-2022 — Yolk sac, 3080-3082, 3554-3555.
Virchow, R.— Evolution, 3191 — Heredity, 1147 — Placenta, 2250 — Skull, 2538.
Viti, A.— Amnion, 41.
Vockeroth, C.— Amnion, 42.
Voeltzkow, A. P.— Invertebrates, 1351-1352 — Reptiles, 2305, 3410.
Vogt, C.— Teleosts, 2818.
Vogt, J. G.— Evolution of man, 692.
Voll, A.— Eye, 3202.
Vrolik, A. J.— Skull, 2539.
Vrolik, W.— General works, 923.
Wagener, G. R.— Muscles, 1648-1650 — Ovary, 1916.
Wagner, M.— Evolution of man, 693.
Wagner, R.— General works, 925 — Ovary, 1917 — Ovum, 2023.
Wagner, R., *and* Leuckart, R.— Spermatozoa, 2636.
Wagner, R., *and others*.— General works, 924.
Waldeyer, W.— Bone, 308 — Brain, 365 — Cell division, 459 — Connective tissue, 500 — Diaphragm, 540 — General works, 926-927 — Germ layers, 1021 — Heredity, 1148 — Human embryo, 1209 — Impregnation, 1290 — Neuron, 1801 — Ovary, 1918 — Placenta, 2251-2252 — Pregnancy, 3398 — Spermatogenesis, 2589 — Spinal cord, 2669 — Teeth, 2751 — Thymus and thyroid, 3512 — Uterus, 3016-3017.
Walker, A.— Foetal membranes, 817.
Walkhoff.— Teeth, 2752.
Warren, J. C.— Epidermis, 638.
Wasielewski, von.— Ovary, 3362.
Wasman.— Parthenogenesis, 3379.
Watase, S.— Cell division, 3155 — Segmentation of ovum, 2357 — Sex, 3428.
Waters, B. H.— Brain, 366, 3145.
Watson, M.— Placenta, 2253 — Urogenital, 2961.
Weber, E. H.— Urogenital, 2962.
Weber, M.— Epidermis, 3186.
Weibgen, K.— Thymus and thyroid, 3513.
Weigert, C.— Heredity, 1149.
Weil.— Teeth, 2753.
Weil, C.— Mammals, 1544.
Weismann, A.— Heredity, 1150-1153, 3255-3256 — Muscles, 1651-1652 — Ovum, 2024-2027 — Sex, 2379 — Sexuality, 2402-2403.
Weismann, A., *and* Ischikawa.— Impregnation, 1291-1294 — Ovum, 2028-2029.
Weiss, F. E.— Urogenital, 2963.
Wekerle, L.— Evolution of man, 694.
Weleher.— Epidermis, 639.
Weldon, W. F. R — Placenta, 2254 — Reptiles, 2306 — Supra-renals, 2689-2690 — Wolffian body, 3067.
Wenckebach, K. F.— Blood, 249 — Reptiles, 2307 — Teleosts, 2819.
Werth — Pregnancy, 2264 — Uterus, 301.
Wertheimer, E.— Liver, 1417.
White, M. C.— Blood, 250.
White, W. H — Evolution of man, 695.
Whitman, C. O.— Cells, 423 — Germ layers, 1022 — Impregnation, 1295-1296 — Invertebrates, 1353-1355 — Ovum, 2030-2031.
Wiedersheim, R — Amphibia, 83-84 — Brain, 367 — Evolution of man, 696— General works, 928— Limbs, 1412-1414 — Pineal gland, 2064 — Skeleton, 2473, 3435 — Testis, 3507 — Urogenital, 2964.
Wiedersperg, G. von.— Spermatogenesis, 2590.
Wieger, G.— Urogenital, 2965.
Wielowiejski, H. von.— Ovum, 2032-2033.
Wiener, M.— Amnion, 43.
Wijhe, J. W. van.— Amphioxus, 3093 — Head, 1086 — Head kidney, 1098 — Nerves, cephalic, 1737 — Neurenteric canal, 1783 — Urogenital, 2966.
Wilckens, M.— Sex, 2380.
Wilder, B. G.— Brain, 368-369.
Wilder, H. H.— Larynx, 3286 — Nerves, cephalic, 3339.
Wilkins, M.— Heredity, 3257.
Will, L.— Reptiles, 2308-2310, 3411.
Willach, P.— Eye, 758 — Lungs and traehea, 1427.
Willey, A.— Amphioxus, 93-94 — Hypophysis, 3262.
Williams, J.— Ovulation, 1930 — Teeth, 2754 — Uterus, 3019-3020.
Wilson, A.— Sex, 3429.
Wilson, E. B.— Amphioxus, 3094 — Annelids, 95-96, 3095 — Invertebrates, 1356.
Wilson, H. V.— Teleosts, 2820.
Windle, B. C. A.— Impregnation, 1297 — Teratology, 3500.
Winkler, F. N.— Amnion, 44-46 — Placenta, 2255.
Winogradow.— Amnion, 47.
Winter, G.— Pregnancy, 2265.
Wirth, A.— Vertebrae, 3543.
Wissozky, N.— Blood, 251.
Wittich.— Urogenital, 2967.
Wölfler, A.— Thymus and thyroid, 2859.
Wolff, C. F.— Archenteron, 121.

Wolff, J.— Bone, 309, 3133.
Wolff, W.— Germ layers, 1023.
Wolska, W.— Decidua, 529.
Wolters, M.— Cartilage, 383 — Conjugation, 481.
Wood-Mason, J.— Elasmobranchs, 597.
Woodward, M. T.— Teeth, 3487.
Würzburg, A.— Eye, 759.
Wyder, A. T.— Uterus, 3021.
Wyman, J.— Amphibia, 3088 — Elasmobranchs, 3181.
Young, A. H.— Placenta, 2256.
Yung, E — Sex, 2381.
Zacharias, O.— Evolution of man, 697 — Impregnation, 1298-1299.
Zander, R.— Epidermis, 610 — Nails, 1670-1671.
Zander, V. R., *and* Stieda.—Veins, 3530.
Zarmella, E.— Placenta, 2257.
Zeutler, M.— Growth, 1038.
Ziegenspeck, K.—Blood, 252.
Ziegler, F.— Amphibia, 85.
Ziegler, H. E.— Blood, 253-254, 3122 — Cell division, 460— Germ layers, 1024.
Ziegler, H. E., *and* Rath, O. vom.— Cell division, 461.
Ziegler, H. E., *and* Ziegler, Friedrich.— Elasmobranchs, 598.
Zimmermann, K. W.— Cell theory, 3160.
Zimmermann, W.— Aorta, 116-117 — Connective tissue, 501 — Human embryo, 1210 — Myotomes, 1664.
Zoerner, E.— Coelom, 476.
Zuckerkandl, E.— Nose, 1819-1820 — Skull, 3142 — Teeth, 2755.
Zumstein, J. J.— Germ layers, 1025.
Zwaardemacker.— Lymphatics, 1434.
Zweifel.— Meconium, 1572.
Zycki, A.— Amniotic fluid, 57.

INDEX.

	Page
Acantherpestes inequalis	424
major	424
Acanthopanax ricinifolium	237
Acer pictum	223
spicatum	223
Achillea macrocephala	241
millefolium	241
ptarmica	241
sibirica	241
Aconitum fischeri	216
Actinoceramus	391
Actinopteria	386, 391
Adenophora verticillata	246
Aegopodium alpestre	235
Aenigma	389, 391
Agrimonia eupatoria	232
Agrostis canina	269
perennans	269
Alectryonia	385, 391
Allium victorialis	264
Alnus incana	259
viridis	259
Alopecurus geniculatus	269
Amusium	388, 391
Anaphalis margaritacea	241
Androsace villosa	250
Anemone debilis	214
narcissiflora	215
parviflora	214
Angelica anomala	236
Anodon	367
Anomia	354, 359, 388, 391
Anthracoblattina triassica	464
Anthracomarti	443
Anthracomartus pustulatus	452
trilobitus	451
Anthriscus sylvestris	236
Arabis ambigua	217
lyrata	217
perfoliata	217
stelleri	217
Arachnida, carboniferous	443
Aralia racemosa	237
Archimylacris paucinervis	411
Architarbus elongatum	149
rotundatum	149
Archiulus glomeratus	436
sp.	437
Arctostaphylos uva-ursi	247
Arenaria lateriflora	221
peploides	221
Argina	364
Armeria vulgaris	249
Artemisia glomerata	242
laciniata	242
norvegica	243
sericea	243
stelleriana	243
vulgaris	243
Aruncus sylvester	227
Asperula odorata	239
Aspidium fragrans	274
Asplenium filix-foemina	274
spinulosum	275
Aster glehni	240
Astilbe thunbergii	233
Atrina	385, 391
Avicula	327, 379, 382, 391
Aviculidae	277, 379
Aviculopecten	387, 391
Aviculopinna	391
Bakewellia	384, 391
Bambusa kurilensis	271
Barbarea vulgaris	217
Basidiobolus ranarum	191
Betula alba	259
ermani	259
Bibliography of vertebrate embryology	487
Bone structure	1
Boschniakia glabra	255
Botrychium lunaria	273
ternatum	274
Brunella vulgaris	255
Bryanthus taxifolius	247
Campanula rotundifolia	245
Campbell, D. H. Development of the ostrich fern	17
Caprinula	323
Caprotina	323
Capsella bursa-pastoris	219
Carboniferous Arachnida	443
Carboniferous deposits, cockroaches from	401
Carboniferous Myriapoda from Illinois	417
Cardamine pratensis	217
Carex gmelini	268
macilenta	268
macrocephala	268
microglochin	267
rhynchophysa	268
rotundata	268
transversa	268
vaginata	268
Carolia	389, 391
Cassianella	382, 391
Cassiope lycopodioides	247
Cerastium alpinum	220
semidecandrum	220
vulgatum	220
Cercopyllis adolescens	472
delicatula	471
justiciae	471
Chama	323
Chamostrea	323
Chenopodium album	257
Chlamys	388, 391
Chrysanthemum arcticum	242
Chrysosplenium kamtschaticum	234
Cimicifuga simplex	216
Circaea alpina	235
Claytonia sarmentosa	222
Clematis alpina	213
fusca	213
Clintonia udensis	265
Cnicus kamtschaticus	244
Cockroaches from carboniferous deposits	401
Coelopleurum gmelini	236
Convallaria majalis	264
Coptis trifolia	216
Cornus canadensis	237
suecica	237
Corydalis ambigua	162
ochotensis	216
Crawfurdia japonica	215

Page

Crenella . . 364
Crenipecten 388, 391
Cynoglossum furcatum . 252
Cystopteris fragilis . . . 274
Deschampsia flexuosa . 269
Dianthus alpinus . . 219
superbus 220
Diapensia lapponica . . 248
Diervilla middendorffiana . 239
Dimya . . . 324, 389, 391
Disporum smilacinum . . 265
Dodecatheon meadia . . 249
Draba borealis . . . 218
gelida . . . 218
hirsuta . . . 218
Dwight, T. Fusion of hands 473
——— Significance of bone structure 1
Echinochama . . . 370
Eileticus aequalis . . 421
anthracinus . . 420
Elymus mollis . . . 271
Embryology, bibliography of vertebrate 487
Empetrum nigrum . . 260
Empusa americana . 179
aphidis . . . 175
apiculata . . 163
caroliniana . . 167
conglomerata . . 162
conica . . . 186
culicis . . . 157
dipterigena . . 177
echinospora . . 180
fresenii . . . 167
geometralis . . 170
gracilis . . 185
grylli . . . 159
jassi . . . 187
lageniformis . . 169
lampyridarum . 169
montana . . . 180
muscae . . . 155
occidentalis . . 171
papillata . . 166
planchoniana . . 165
rhizospora . . 183
sepulchralis . . 181
sphaerosperma . 172
tenthredinis . . 162
variabilis . . 183
virescens . . 178
Entomophthora calliphorae 188
colorata . 187
curvispora . 189
muscivora . 188
ovispora . 188
pelliculosa . 189
phryganeae 189
tipulae . 188

Page

Entomophthoreae . . 133
Epilobium angustifolium . 235
behringianum . 235
bongardi . . 235
lactiflorum . . 235
latifolium . . 235
Equisetum arvense . . 273
hyemale . . 273
limosum . . 273
variegatum . 273
Erigeron salsuginosus . . 240
Erodium botrys . . 81
ciconium . . 81
cicutarium . 82
macrophyllum . 81
malachoides . 81
moschatum . . 81
texanum . . 81
Etoblattina occidentalis . 410
persistens . 459
sp. . . . 460
Euphoberia anguilla . . 435
armigera . . 427
carri . . . 429
cuspidata . . 429
flabellata . . 426
granosa . . 427
hystricosa . 426
simplex . . 432
sp. . . . 435
spinulosa . . 430
tracta . . 433
Euphrasia officinalis . . 254
Evonymus alata . . . 223
macroptera . 223
Exogyra . . . 317, 385, 391
Festuca ovina . . . 271
rubra . . . 271
Filipendula kamtschatica . 228
palmata . . 228
Floerkea proserpinacoides 85
Fritillaria kamtschatcensis 265
Galeopsis tetrahit . . 255
Galium kamtschaticum . 239
verum . . . 239
Gentiana auriculata . 251
glauca . . . 251
Georgia, Taconic of . . 105
Geralinura carbonaria . . 455
Geraniaceae 71
Geranium caespitosum . 75
carolinianum . 76
columbinum . 76
dissectum . . 77
erianthum . 74, 222
fremontii . . 75
hernandezii . . 76
incisum . . 74
maculatum . . 74
molle . . . 77

Page

Geranium pratense . . 75
pusillum . . 77
richardsonii . 75
robertianum . 78
rotundifolium . 77
sibiricum . . 76
yesoense . . 222
Geraphrynus carbonarius . 446
Geratarbus lacoei . . 448
scabrum . . 448
Gervillia . . . 384, 391
Geum macrophyllum . . 230
strictum . . . 229
Glyceria festucaeformis . 270
Graeophonus carbonarius . 454
Gryphaea . . . 317, 391
Habenaria conopsea . . 262
minor . . . 263
ussuriensis . . 263
Hands, fusion of . . . 473
Hemerocallis middendorffi . 264
Heracleum lanatum . . 236
Hierochloe borealis . . 269
Hinnites . 324, 350, 390, 391
Hornesia 391
Hydrangea scandens . . 234
Hypericum erectum . 222
Ilex crenata 223
rugosa . . . 223
Ilyodes elongata . . . 423
Impatiens fulva . . . 99
nolitangere . . 222
pallida . . . 99
Inoceramus . . . 384, 391
Iris setosa 263
Jackson, R. T. Phylogeny of the Pelecypoda . . 277
Juncus articulatus . . 266
balticus . . . 266
effusus . . . 266
Juniperus communis . . 260
Kurile Islands, flora of . 203
Kustarachne tenuipes . . 450
Lactuca repens . . . 245
sibirica . . . 245
thunbergii . . 245
Larix dahurica . . . 261
Lathyrus maritimus . . 225
palustris . . 225
Latzelia primordialis . . 419
Ledum palustre . . . 248
Leptodesma . . 381, 391
Leucothoe grayana . . 247
Ligusticum scoticum . . 236
Lilium avenaceum . . 265
cordifolium . . 264
dahuricum . . 264
Lima . . . 353, 388, 391
Limnanthes alba . . . 84
douglasii . . . 85

Page

Limnanthes macounii . 85
rosea . 85
Linaria japonica . . 253
Linnaea borealis . . . 238
Liparis schmidtii . . 262
Lithomylacris pauperata . 409
Lonicera caerulea . . 238
chamissoi . . 239
maximowiczii . 238
Lupinus nootkatensis . 224
Luzula campestris . 267
pilosa . . . 267
Lychnis affinis . . . 220
Lycopodium annotinum . 272
clavatum . . 272
complanatum . 272
japonicum . 272
Lyriopecten . . . 387, 391
Lysichiton kamtschatcensis 267
Maianthemum bifolium . 264
Malleus . . . 383, 391
Marcou, J. Taconic of Georgia and Report on the geology of Vermont . . 105
Margaritana 366
Massospora cicadina . . 190
Matricaria ambigua . . 242
discoidea . . 242
Meleagrina 391
Melica nutans . . . 270
Menyanthes trifoliata . . 251
Mertensia maritima . . 252
paniculata . . 252
rivularis . . 252
sibirica . . 252
stylosa . . 252
Microstylis monophyllos . 262
Mimulus ringens . . . 253
Minot, C. S. Bibliography of vertebrate embryology . 487
Miyabe, K. Flora of the Kurile Islands . . . 203
Modiola 364
Monopleura 323
Monotis 391
Mulleriaceae . . . 324
Mya arenaria . . . 372
Mylacris mansfieldii . 401
Myosotis intermedia . . 253
Myriapoda, carboniferous, from Illinois . . . 417
Mytilus 363
Neorthroblattina albolineata 467
attenuata . 468
lakesii . 468
rotundata 468
Onoclea struthiopteris . 17
Orchis aristata . . . 262
Oryctoblattina occidua . 414
Ostrea 294, 303, 311, 317, 325, 384

Page

Ostrea . . . 391
Ostrich fern . . . 17
Oxalis acetosella . . 90, 222
berlandieri . . 87
corniculata . . 88
decaphylla . 91
dichondraefolia . 87
divergens . . . 91
latifolia . . . 91
recurva . . . 89
suksdorfii . . . 89
trilliifolia . . . 90
vespertilionis . . 91
violacea . . . 90
wrightii . . . 88
Oxytoma . . . 382, 391
Oxytropis pumilio . . 224
Palaeopinna . . . 385, 391
Palenarthrus impressus . 422
Parnassia palustris . . 234
Paromylacris ampla . . 408
rotunda . 406
Parrya macrocarpa . . 216
Pecten 333, 342, 350, 379, 387, 391
Pedicularis amoena . . 254
chamissonis 254
euphrasioides 255
resupinata . 254
verticillata 254
Pedipalpi 453
Pedum 390, 391
Pelecypoda, phylogeny of the 277
Perna . . 327, 379, 383, 391
Pernopecten . . . 391
Peruostrea . . . 325, 384
Petasites japonicus . . 243
Petrablattina aequa . . 465
meieri . . 465
Petricola 370
Phalaris arundinacea . . 269
Phragmites communis . 270
Picea obovata . . . 261
Pieris japonica . . . 245
Pieris rapae, spread of . 53
Pinna 385, 391
Pinus parviflora . . . 261
pumila . . . 261
Placuna . . . 389, 391
Placunanomia . . 389, 391
Plantago kamtschatica . 256
major . . . 256
Pleurospermum austriacum 236
Plicatula . 325, 352, 391, 392
Poa annua 270
glumaris . . . 270
laxa 270
pratensis . . . 270
Poliochera punctulata . . 144
Polygonatum humile . . 263
Polygonum amphibium . 257

Page

Polygonum aviculare . 257
viviparum 257
weyrichii . 257
Polypodium vulgare . 274
Populus tremula . . 260
Poroblattina arcuata . 466
lakesii . 466
Potentilla anserina . 232
fragarioides 230
fragiformis . 231
fruticosa . . 230
Primula cuneifolia . . 249
farinosa . . . 249
Promylacris ovalis . . 404
rigida . . 404
testudo . . 403
Prunus ceraseidos . . 226
maximowiczii . . 226
sp. 227
ssiori . . . 226
Pseudomonotis . . 382, 391
Pterinea . . . 386, 391
Pterinopecten . . 386, 391
Pteris aquilina . . . 275
Ptychopteria . . 386, 391
Pyrola media . . . 248
minor . . . 248
renifolia . . . 248
secunda . . . 248
Pyrus sambucifolia . . 232
Quercus grosseserrata . . 259
Ranunculus acris . . . 215
japonicus . . 215
Rhododendron chrysanthum 247
kamtschaticum 247
Rhombopteria . . 380, 391
Rhus toxicodendron . . 224
trichocarpa . . 224
Ribes triste 234
Rosa acicularis . . . 232
rugosa 232
Rubia tatarica . . . 239
Rubus chamaemorus . . 228
idaeus . . . 228
occidentalis . . 229
Rudistae 324
Rumex acetosa . . . 258
graminifolius . . 258
Salix caprea 260
stipularis . . . 260
Salsola soda . . . 257
Sambucus racemosa . . 238
Sanguisorba tennifolia . . 232
Saxicava 372
Saxifraga bronchialis . 233
fusca . . . 233
merkii . . . 233
reflexa . . . 233
Scrobicularia . . 372
Scropinularia alata . . 253

	Page
Scudder, S. H. Carboniferous Myriapoda from Illinois	417
—— Cockroaches from carboniferous deposits	401
—— Illustrations of carboniferous Arachnida	443
—— Insects of the triassic beds at Fairplay, Colorado	457
—— Spread of Pieris rapae	53
Scutellaria galericulata	255
Scutinoblattina brongniarti	469
intermedia	470
recta	470
Sedum kamtschaticum	234
rhodiola	234
Selaginella helvetica	273
Senecio cacaliaefolius	244
davuricus	244
palmatus	244
pseudo-arnica	244
sagittatus	244
Skimmiea japonica	222
Solidago virgaura	240
Sonchus arvensis	245
Sorbaria sorbifolia	227
Sphaerium	369
Spiloblattina gardineri	461
guttata	463
marginata	464
triassica	462
Spiraea betulifolia	227
Spondylus 323, 351, 390,	391
Stachys aspera	256
Stellaria eschscholtziana	221
florida	221
longifolia	221
media	220
radians	220
ruscifolia	221
yezoensis	221
Streptopus amplexifolius	263
Swertia perennis	251
tetrapetala	251
Taconic of Georgia	105
Taraxacum lyratum	245
Tarichium megaspermum	189
uvella	190
Taxus cuspidata	261
Tetrapoma barbaraefolium	218
Thalictrum aquilegifolium	214
minus	214
Thaxter, R. Entomophthoreae of the United States	133
Thermopsis fabacea	224
Tottenia	371
Trelease, W. North American Geraniaceae	71
Triassic beds, insects of	457
Trichites 386,	391
Trientalis europaea	250
Trifolium lupinaster	224
Trillium kamtschaticum	265
Trollius patulus	215
Ulmus campestris	258
Unio	366
Urtica dioica	258
Vaccinium hirtum	247
oxycoccus	246
praestans	246
uliginosum	246
vitis-idaea	246
Venus	371
Veratrum album	266
Vermont, report on geology of	105
Veronica aphylla	253
beccabunga	253
longifolia	253
serpyllifolia	254
stelleri	254
Vertebrate embryology, bibliography of	487
Viburnum opulus	238
Vicia amoena	225
cracca	225
unijuga	225
Viola canina	219
langsdorffii	219
selkirkii	219
verecunda	219
Vola 388,	391
Volviceramus	391
Vulsella 383,	391
Woodsia polystichoides	274
Xylobius frustulentus	438
mazonus	439

ERRATA.

Page 141, 3d line from bottom, *for* condition *read* conditions.

Page 142, line 11, *for* apiculatus *read* apiculata.

Page 143, line 6, *for* apiculatus *read* apiculata.

Page 150, lines 6 and 9, *for* Krasilstchik *read* Krassilstchik.

Page 153, line 11, *after* conica *insert* radicans.

Page 166, line 10, *after* separation *insert* is.

Page 174, line 26, *for* Krasilstchik *read* Krassilstchik.

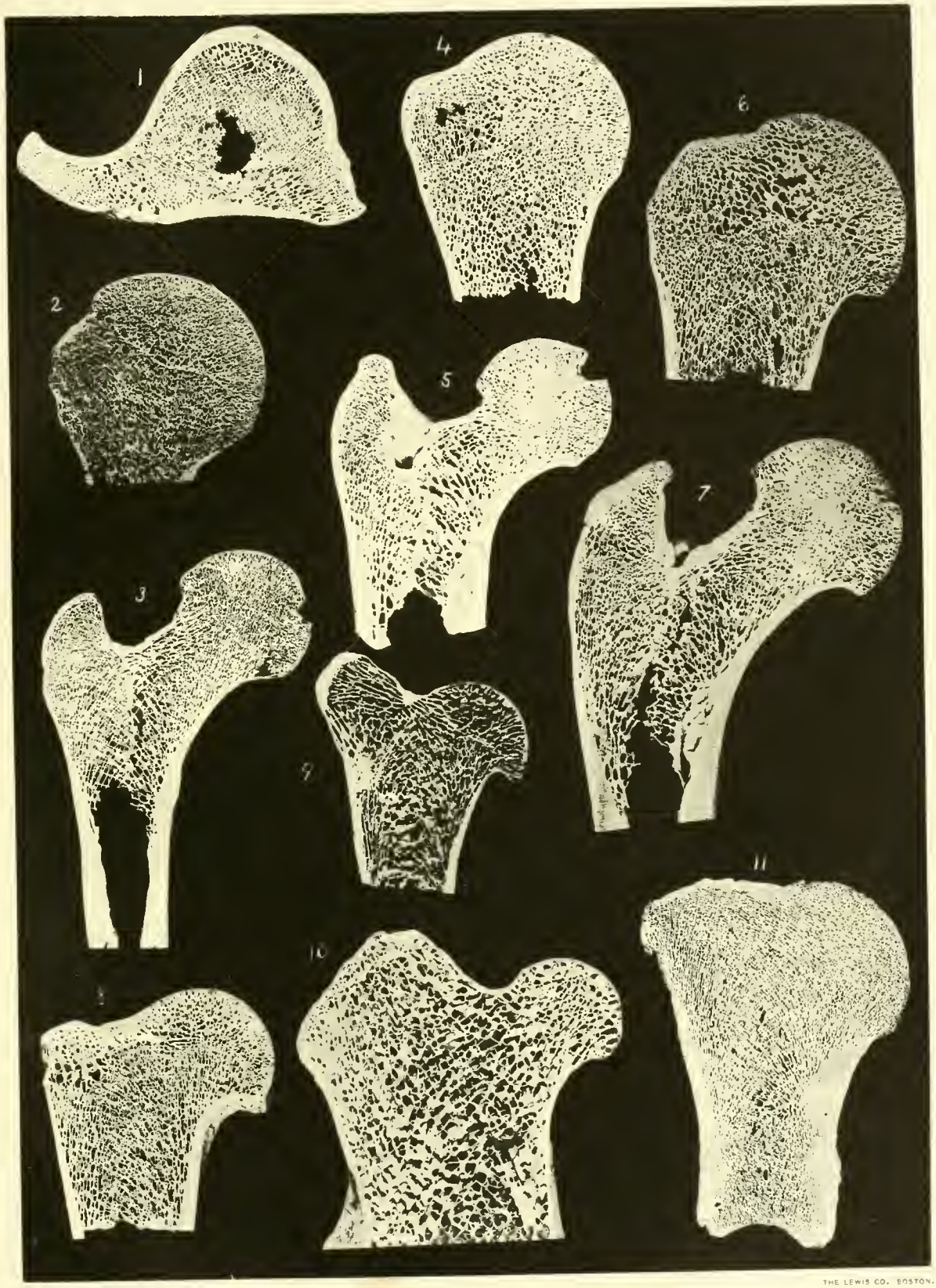
Page 190, line 4, *for* Tarichia *read* Tarichium.

Page 192, line 27, *for* larvae *read* larval.

Page 200, *for* Metarhigium *read* Metarhizium.

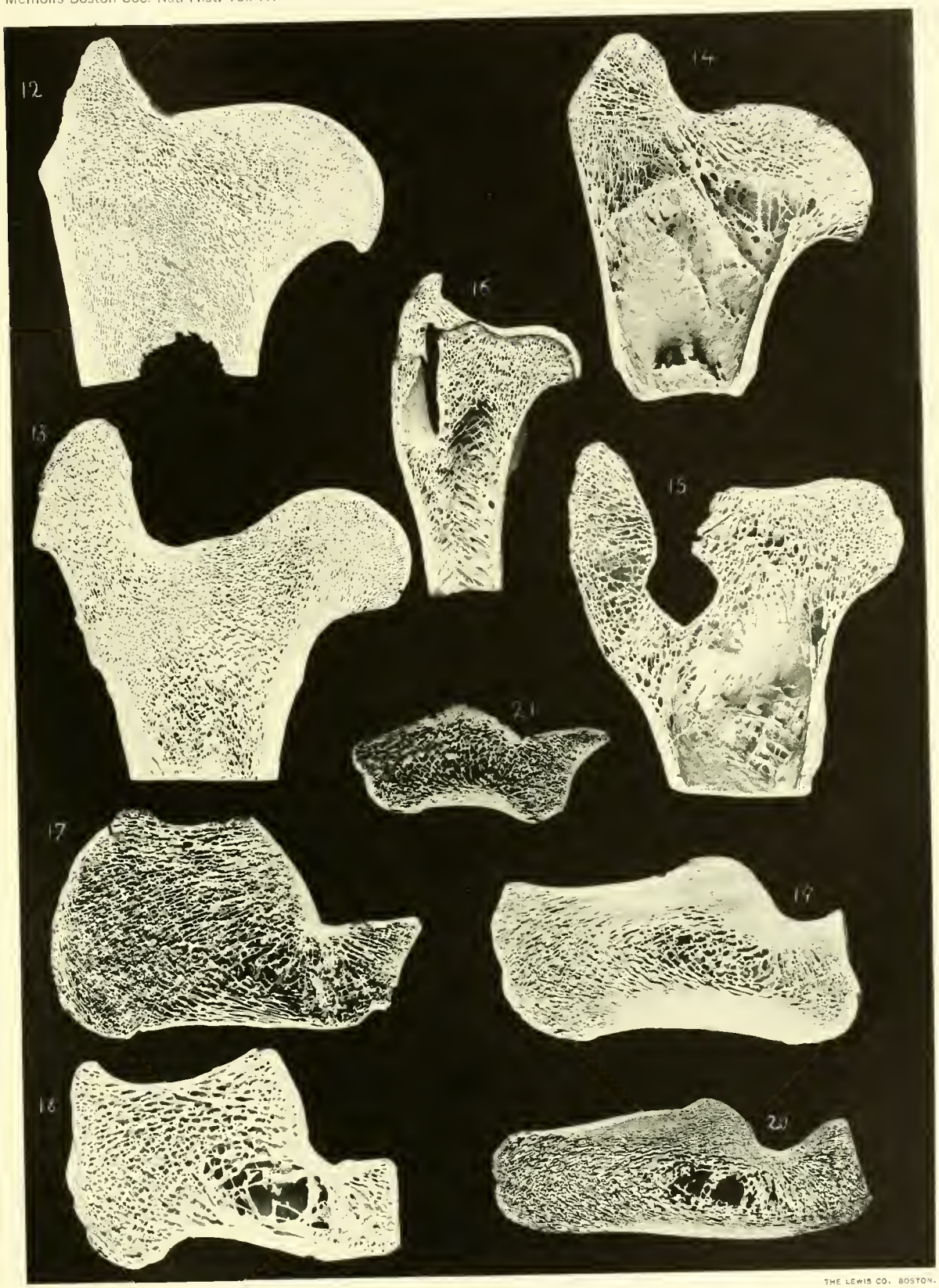
Page 433, line 25, *for* punctae *read* puncta.

Plate XV, *for* var. apiculata *read* apiculata.

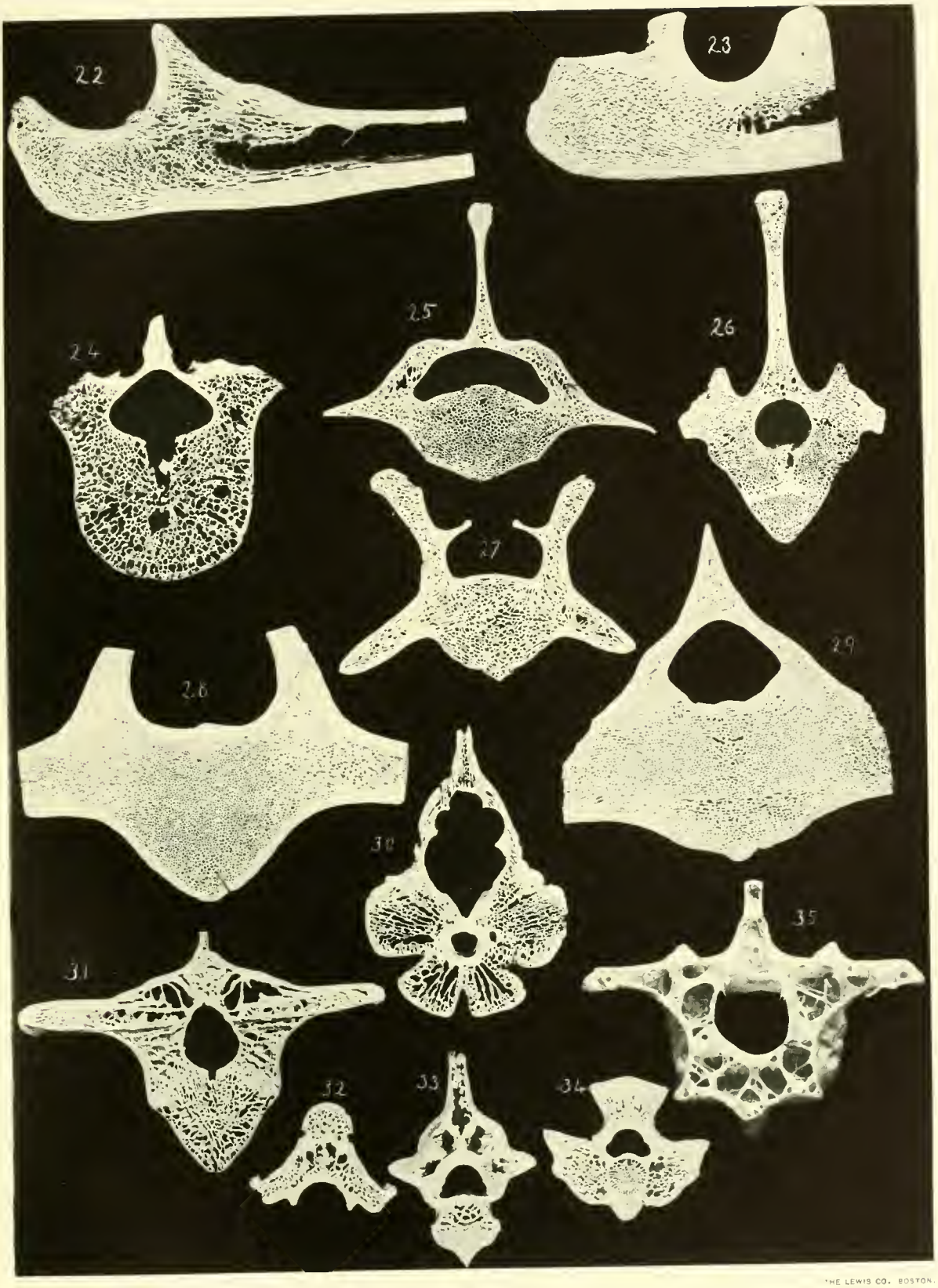


THE LEWIS CO. BOSTON.

DWIGHT, STRUCTURE OF BONE.

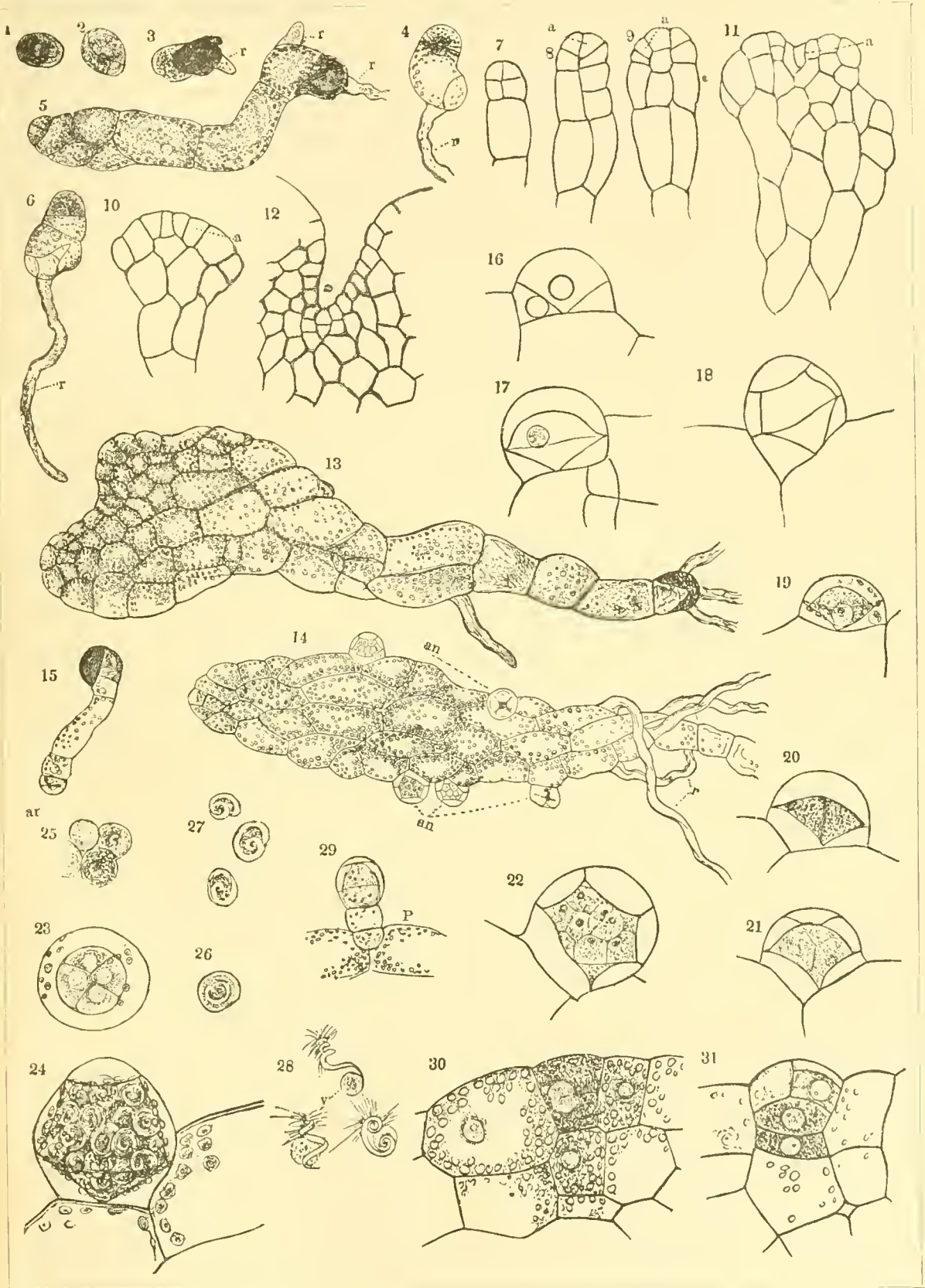


DWIGHT, STRUCTURE OF BONE.

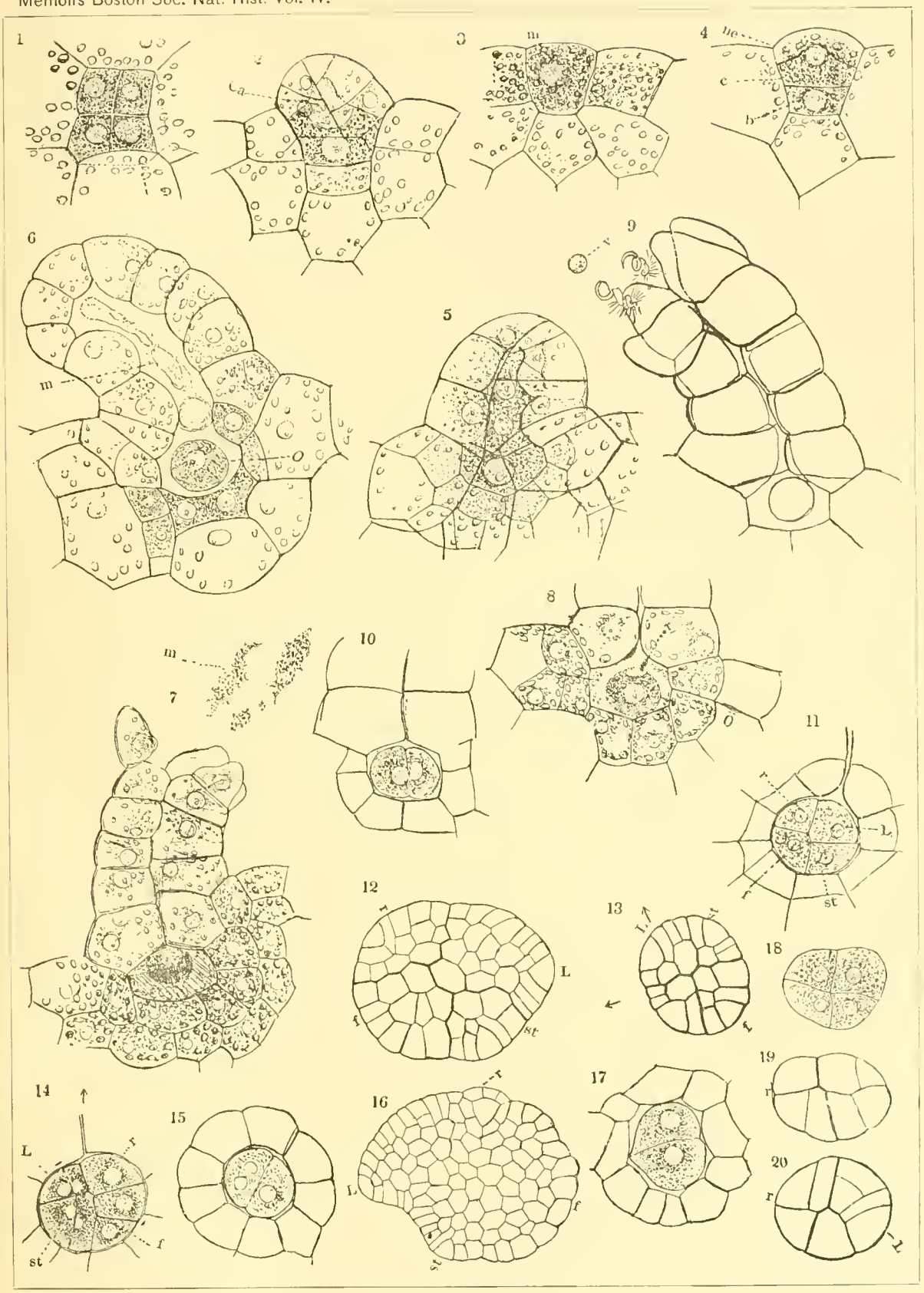


THE LEWIS CO. BOSTON.

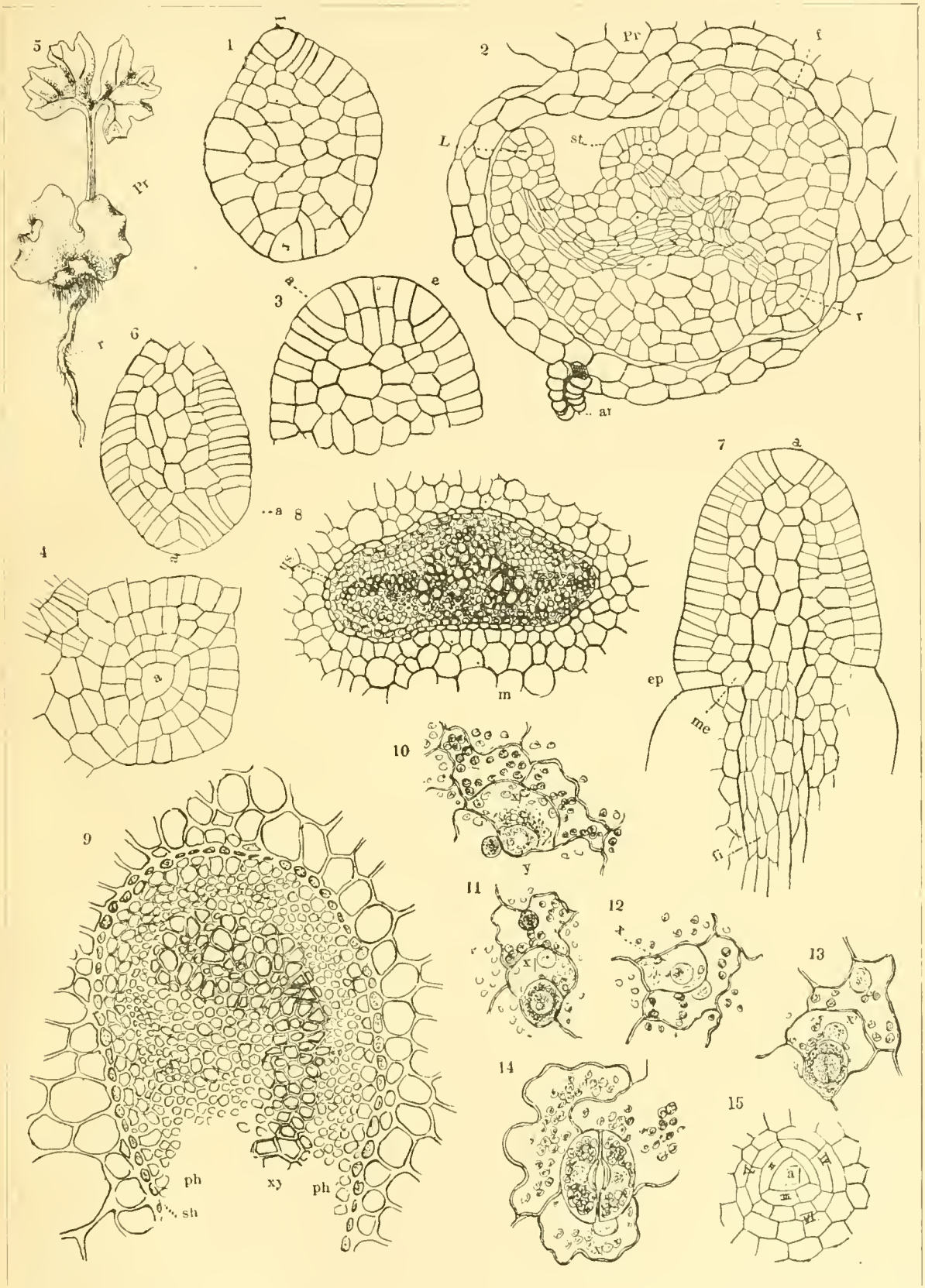
DWIGHT, STRUCTURE OF BONE.



CAMPBELL, DEVELOPMENT OF THE OSTRICH FERN.

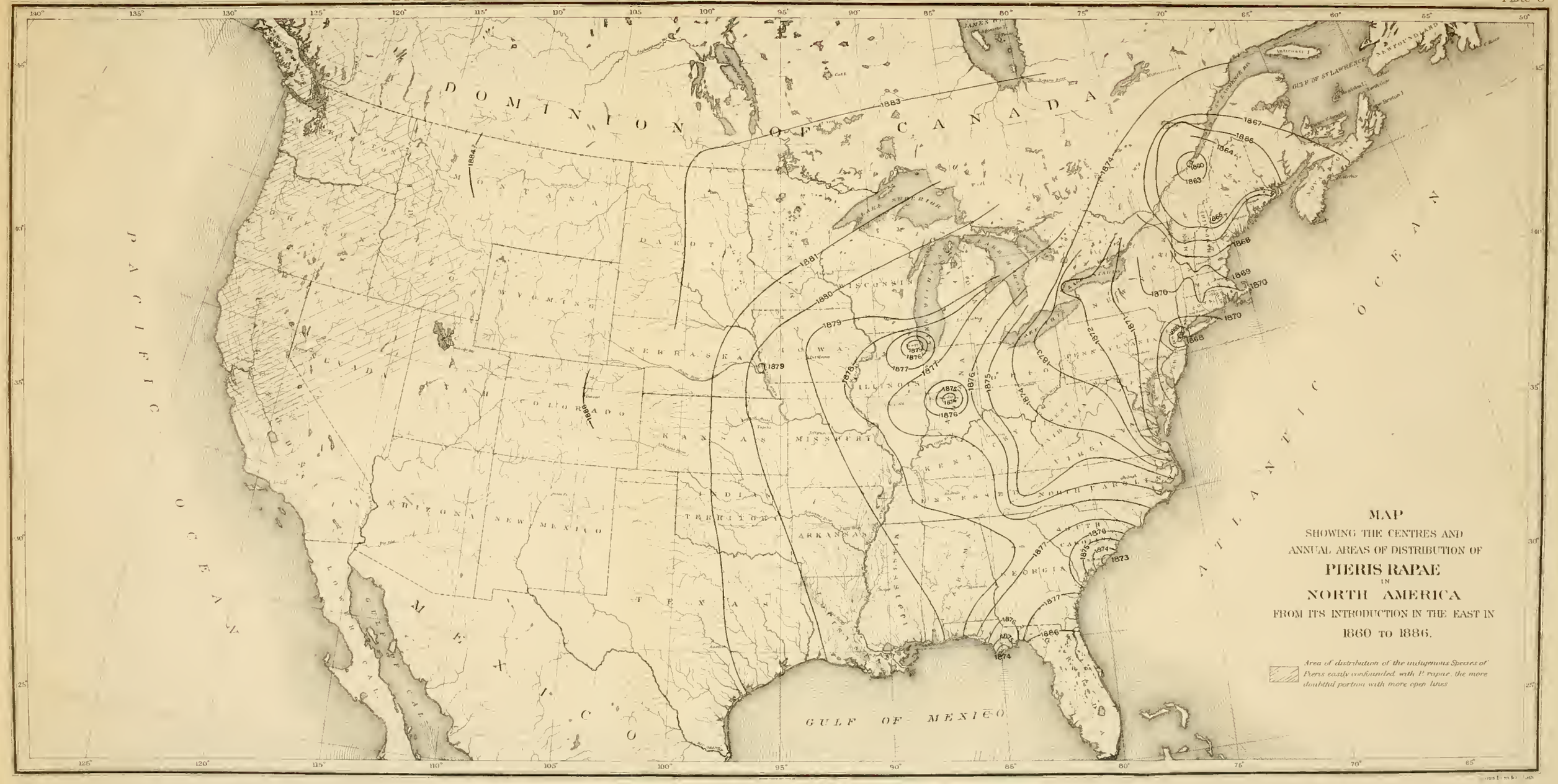


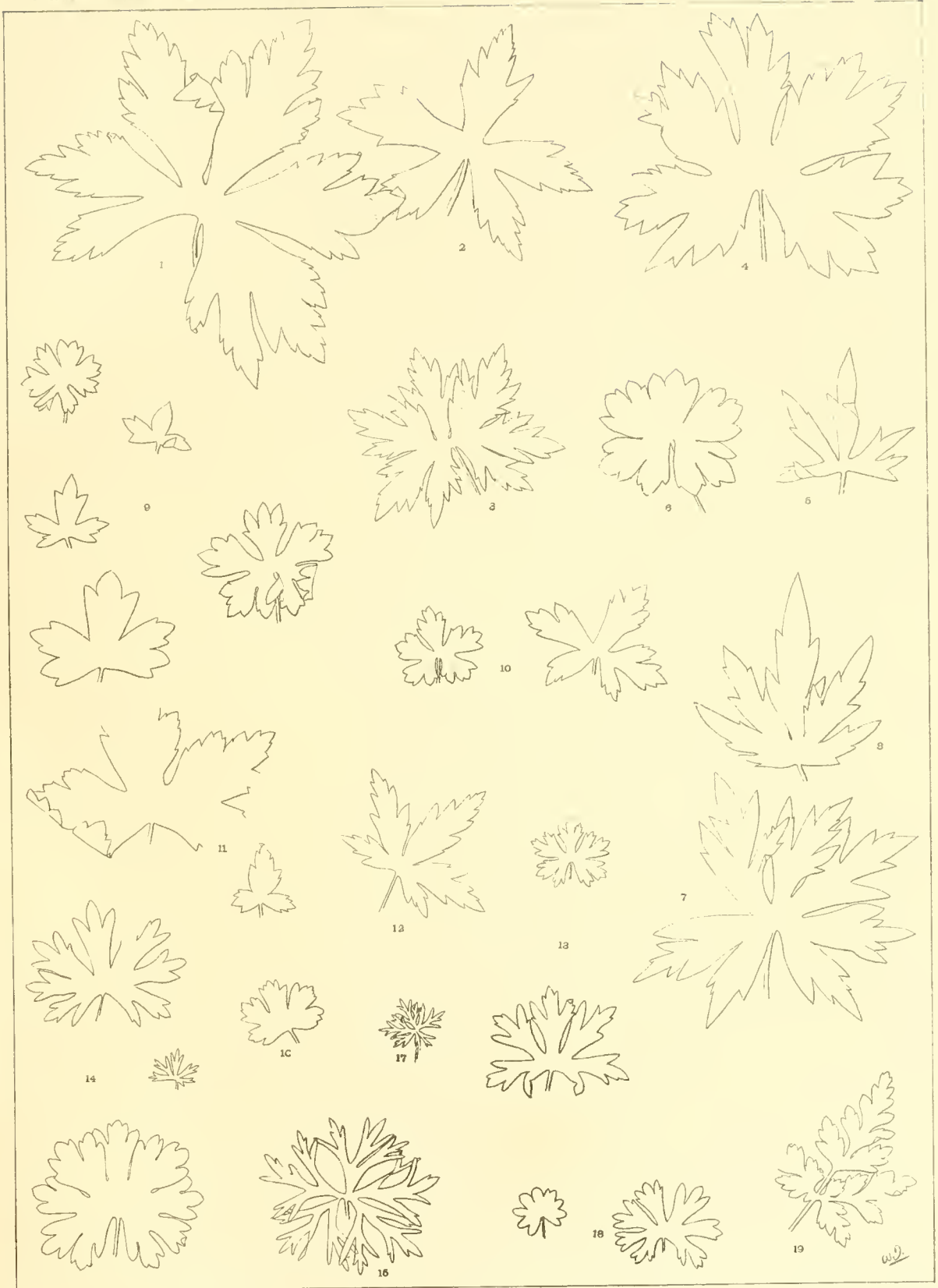
CAMPBELL, DEVELOPMENT OF THE OSTRICH FERN.



CAMPBELL. DEVELOPMENT OF THE OSTRICH FERN.

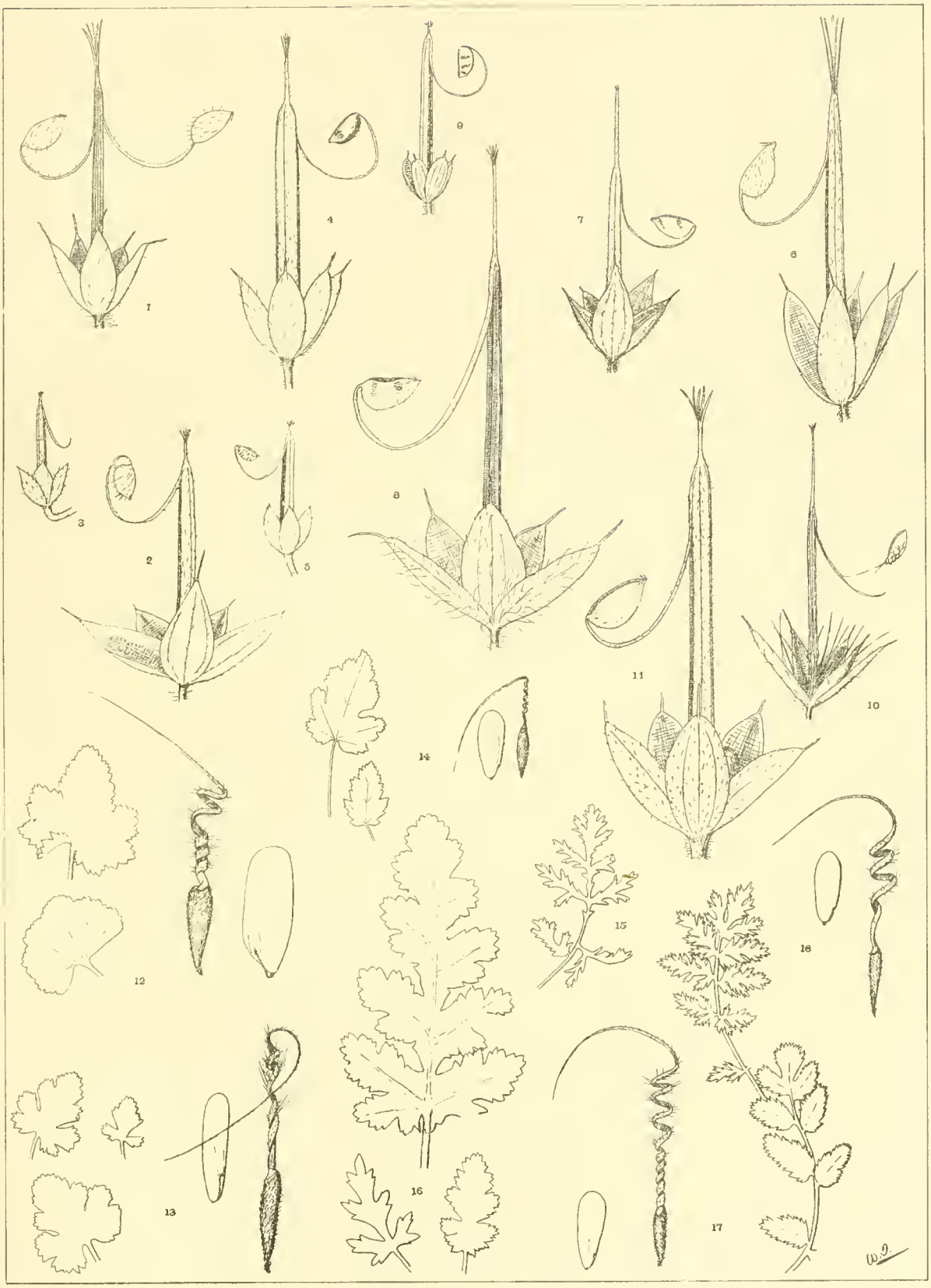
CAMPBELL, DEVELOPMENT OF THE OSTRICH FERN.


DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
GULF OF ST. LAWRENCE
NEWFOUNDLAND
MONTANA
DAKOTA
WYOMING
NEBRASKA
COLORADO
KANSAS
INDIAN TERRITORY
ARKANSAS
TEXAS
ILLINOIS
MISSOURI
GEORGIA
1883
1884
1881
1880
1879
1888
1874
1867
1886
1864
1860
1863
1865
1866
1869
1870
1876
1868
1872
1873
1875
1877
1878
1835
MAP
SHOWING THE CENTRES AND
ANNUAL AREAS OF DISTRIBUTION OF
PIERIS RAPAE
IN
NORTH AMERICA
FROM ITS INTRODUCTION IN THE EAST IN
1860 TO 1886.
Area of distribution of the indigenous Species of Peris easily confounded with P. rapae, the more doubtful portion with more open lines



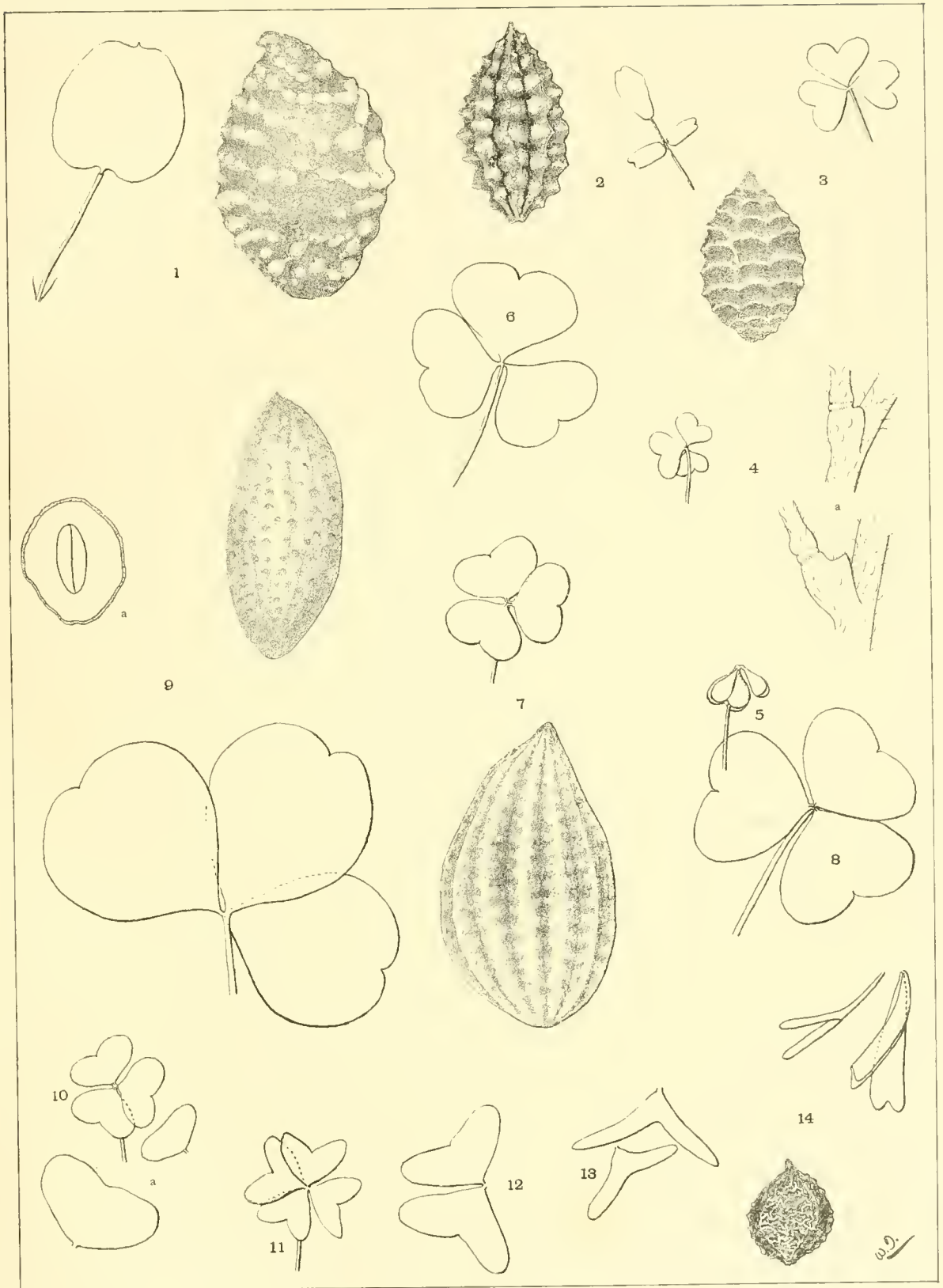
Boston Photogravure Co.

TRELEASE, AMERICAN GERANIACEÆ.



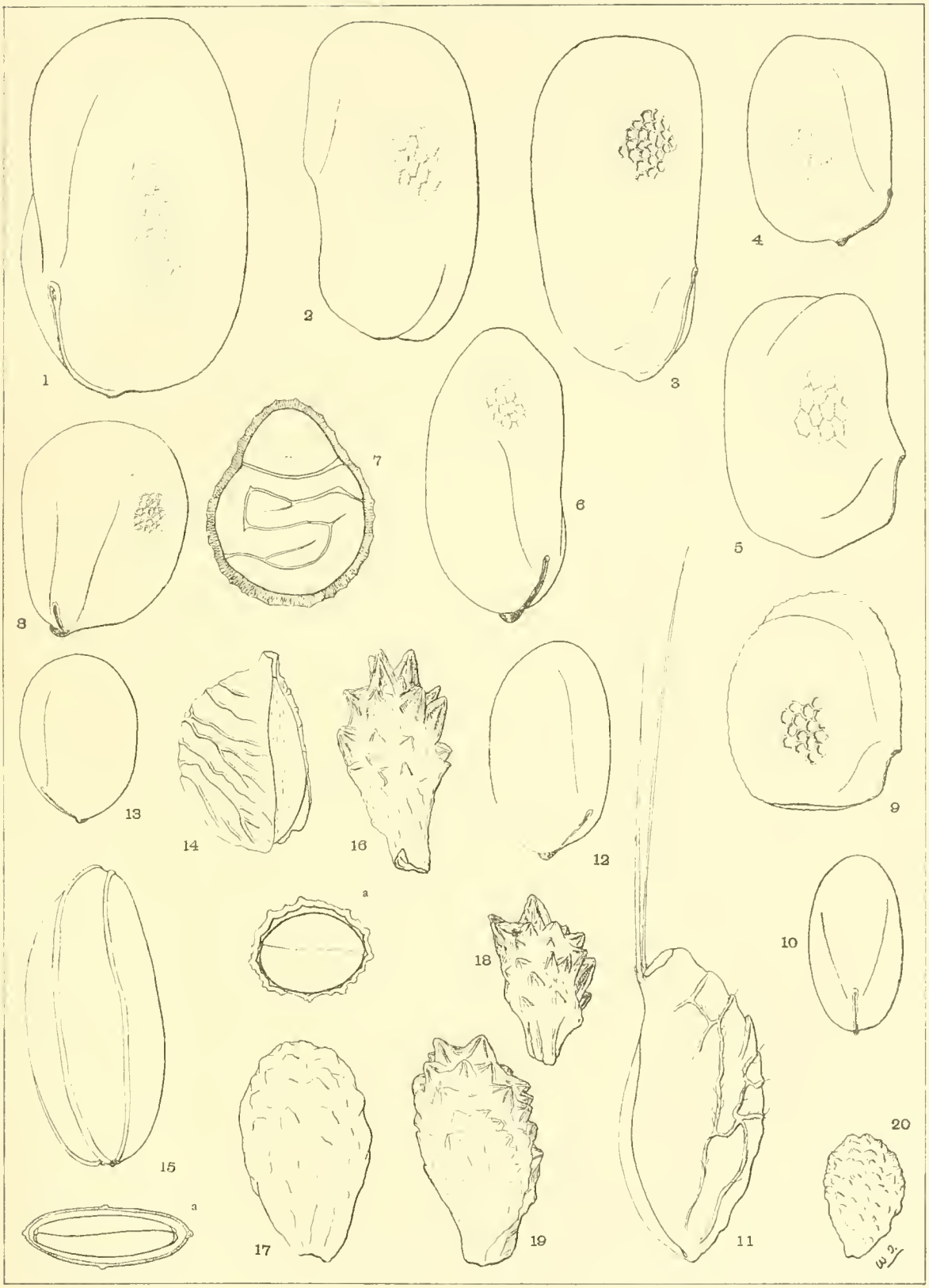
Boston Photogravure Co.

TRELEASE, AMERICAN GERANIACEÆ.



Boston Photogravure Co

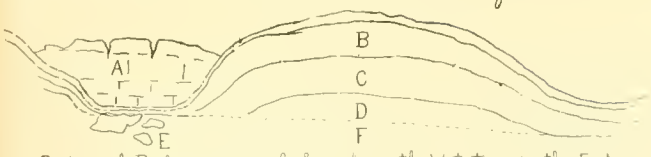
TRELEASE, AMERICAN GERANIACEÆ.



Boston Photogravure Co

TRELEASE, AMERICAN GERANIACEÆ.

Fig 1



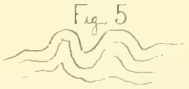
Section of Parker's quarry, looking from the West towards the East.

A Lenticular Sandstone
B Slaty Sandstone
C Grey Slates with Trilobites, Dip 35° East.
D Black Slates
E Loose pieces of the Lentille
F Loose pieces and slabs of Slaty Sandstone

Fig. 4

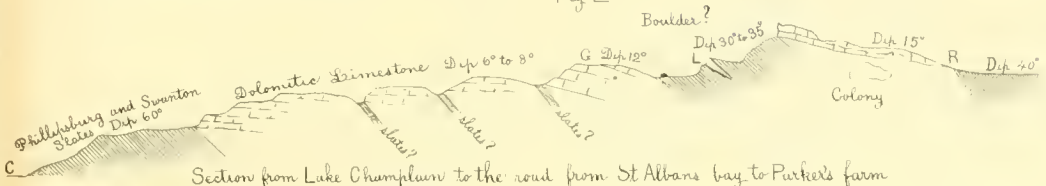
Contorted Calcareous Sandstone at Parker's quarry.

Fig. 5



Contorted Brecciated Limestone at Highgate falls

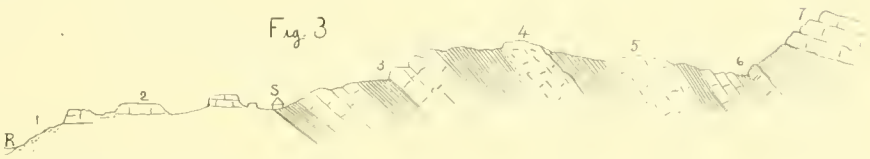
Fig 2



Section from Lake Champlain to the road from St Albans bay to Parker's farm at 200 yards north of the house.

C Lake Champlain
L Lenticular Sandstone with Trilobites
R Road to Parker's house
G Georgia Lenticular Sandrock with Trilobites

Fig. 3



Section from the Missisquoi river (one mile east of Swanton) crossing over Dr. Hall's farm (now Bullard's farm) to the East a little South.

R Missisquoi river
S Sugar cabin

Fig. 6

Contorted Limestone, left side of Highgate falls. The Red Sandrock lies almost horizontally

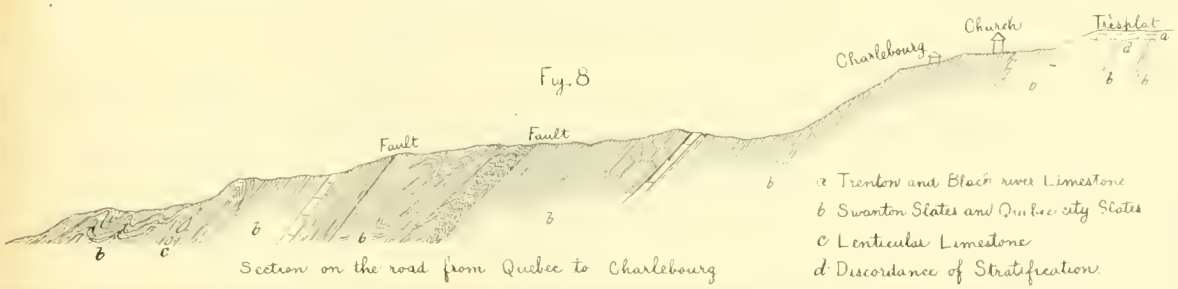
Fig 7

Contorted Slates with Limestone layers, containing Graptolites, at the Hotel Victoria Point Levis (Quebec)

Fig. 4

Supposed overlapping Fault.

Fig. 8



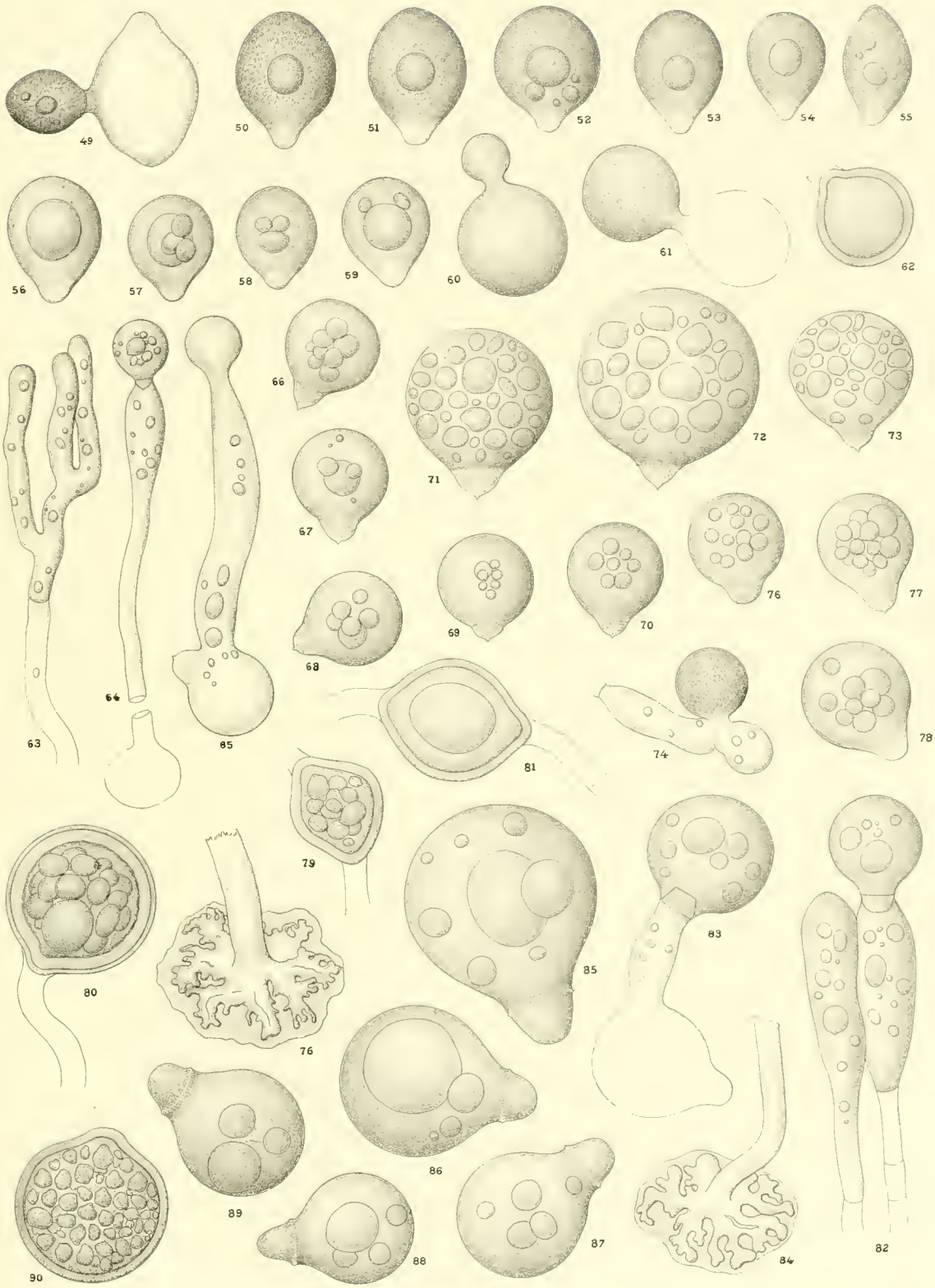
Section on the road from Quebec to Charlebourg

a Trenton and Black river Limestone
b Swanton Slates and Quebec city Slates
c Lenticular Limestone
d Discordance of Stratification

MARCOU'S SECTIONS IN VERMONT AND CANADA

F Thaxter, del ad nat

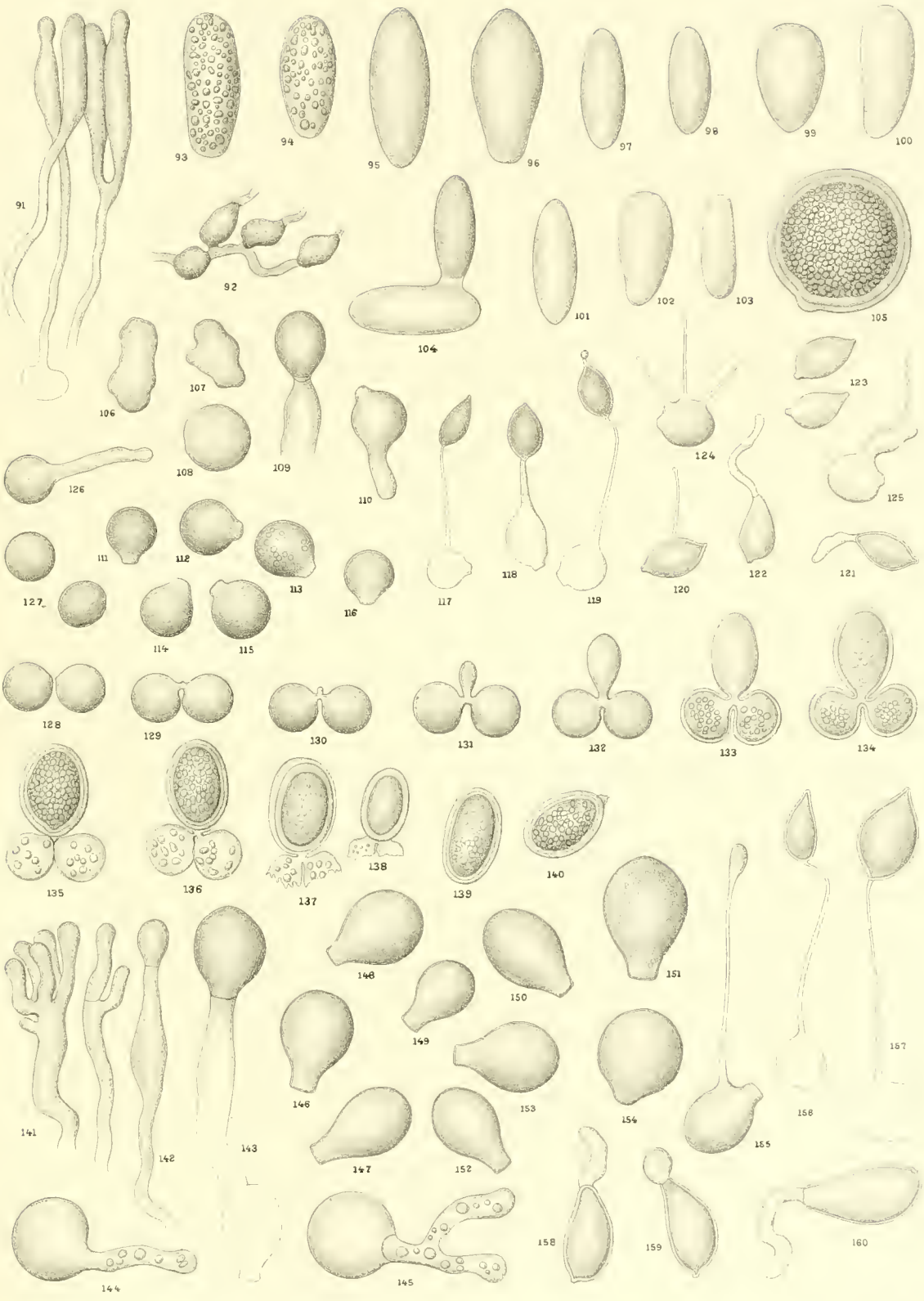
1-9 MUSCÆ. 10-16. CULICIS. 17-48. GRYLLI.



F Thaxter, del ad nat

49-55. TENTHREDINIS. 56-62. CONGLOMERATA ? 62-75 VAR APICULATA.

76-81 PLANCHONIANA ? 82-90. PAPILLATA



H Thaxter, del ad nat

B.Meizel lith

91-105 CAROLINIANA 106 140 FRESENII 141-160 LAGENIFORMIS.

H.Thaxter, del. ad. nat.

161-172. LAMPYRIDARUM. 173-178 GEOMETRALIS 179-199. OCCIDENTALIS

200-219. SPHÆROSPERMA.

Baxter del. ad nat. & Meisel lith.

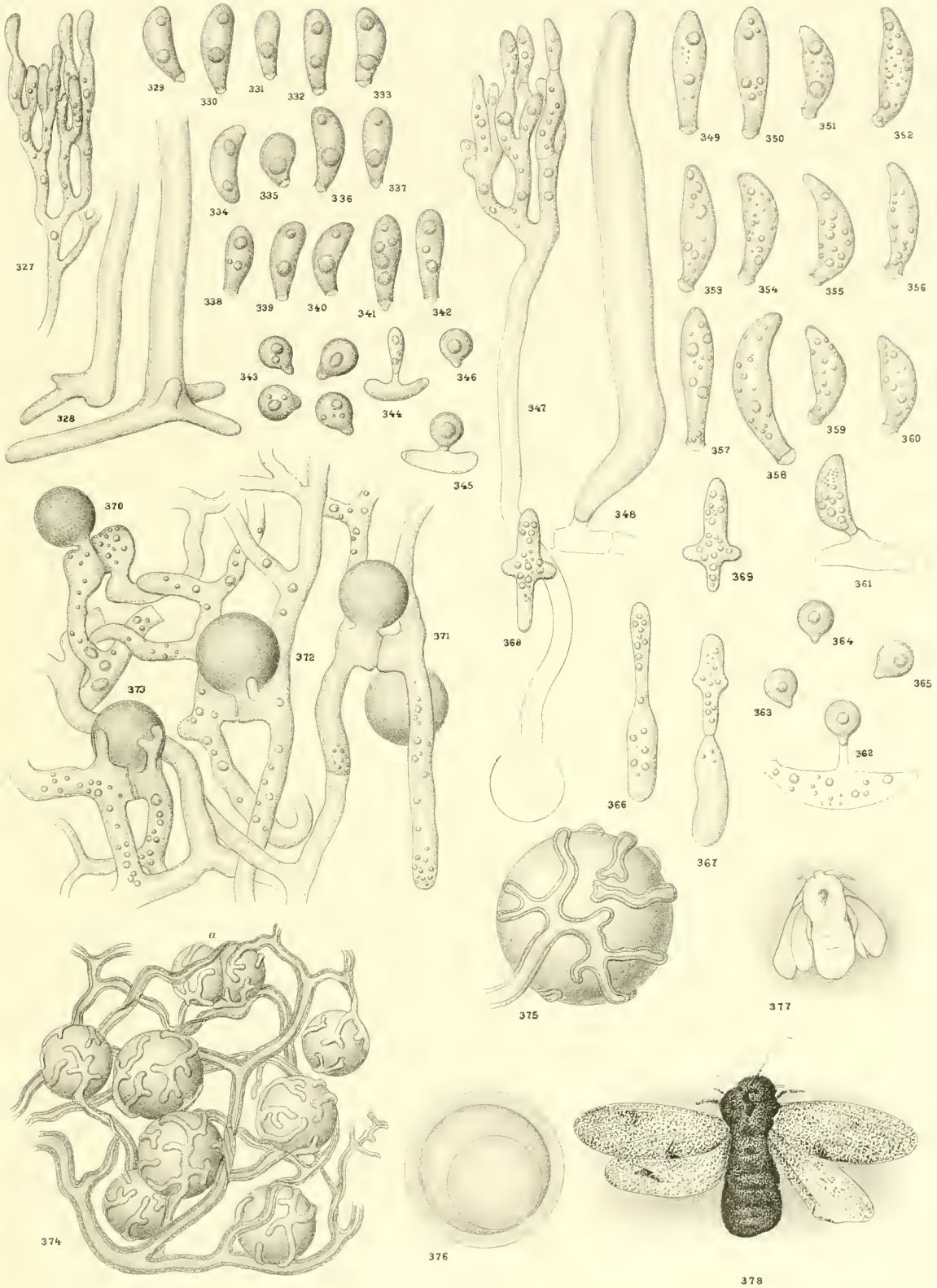
220-240. APHIDIS 241-250 DIFTERIGENA 251-261 VIRESCENS

262-273 AMERICANA 274-285. MONTANA

R Thaxter, del ad nat

B Meisel, lith

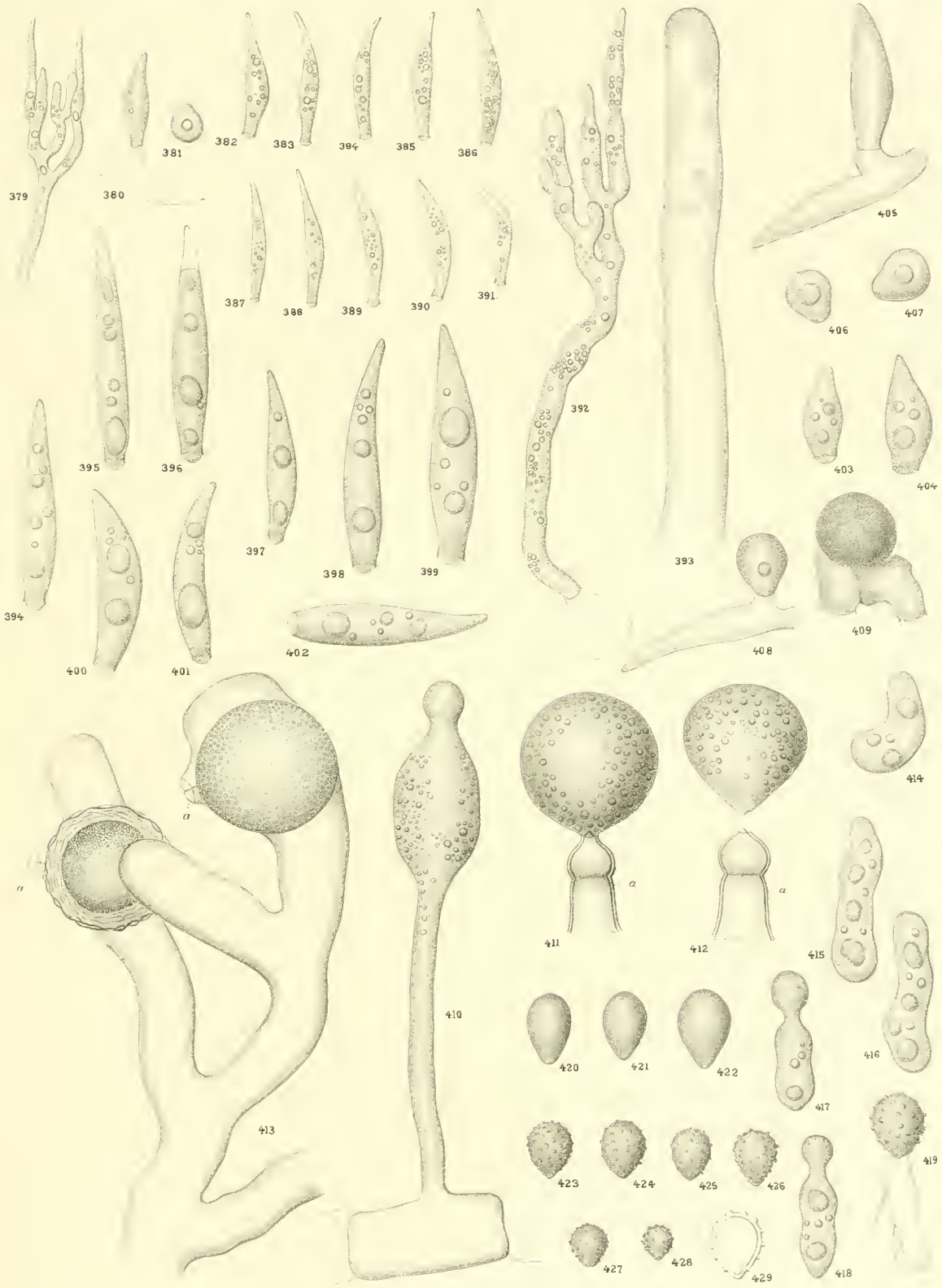
286-305. ECHINOSPORA. 306-326. SEPULCHRALIS



R Thaxter, del. ad. nat.

B. Meisel, lith.

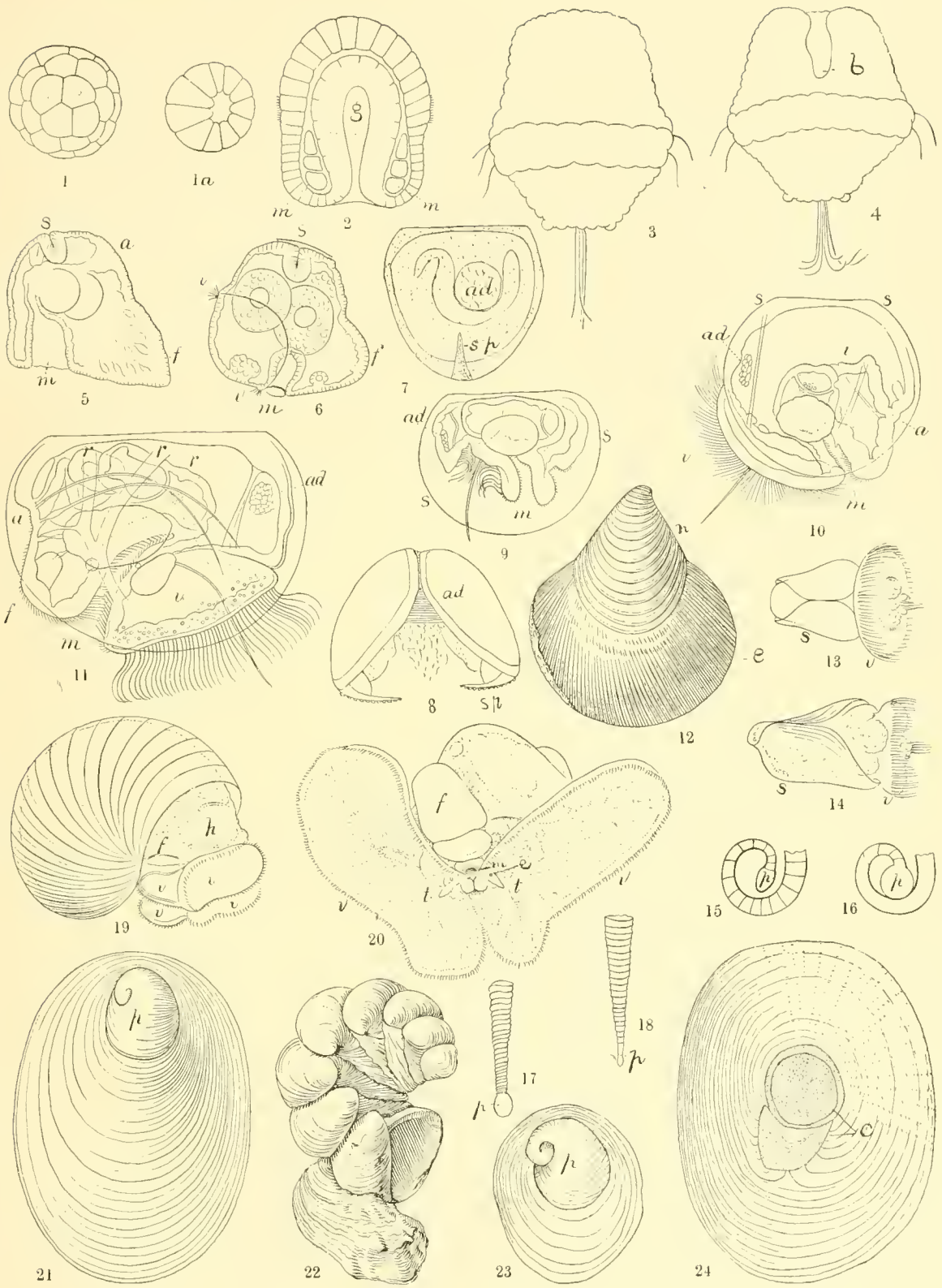
327-346. VARIABILIS 347-378 RHIZOSPORA



379-391. GRACILIS. 392-409 CONICA 410-413. RANARUM.

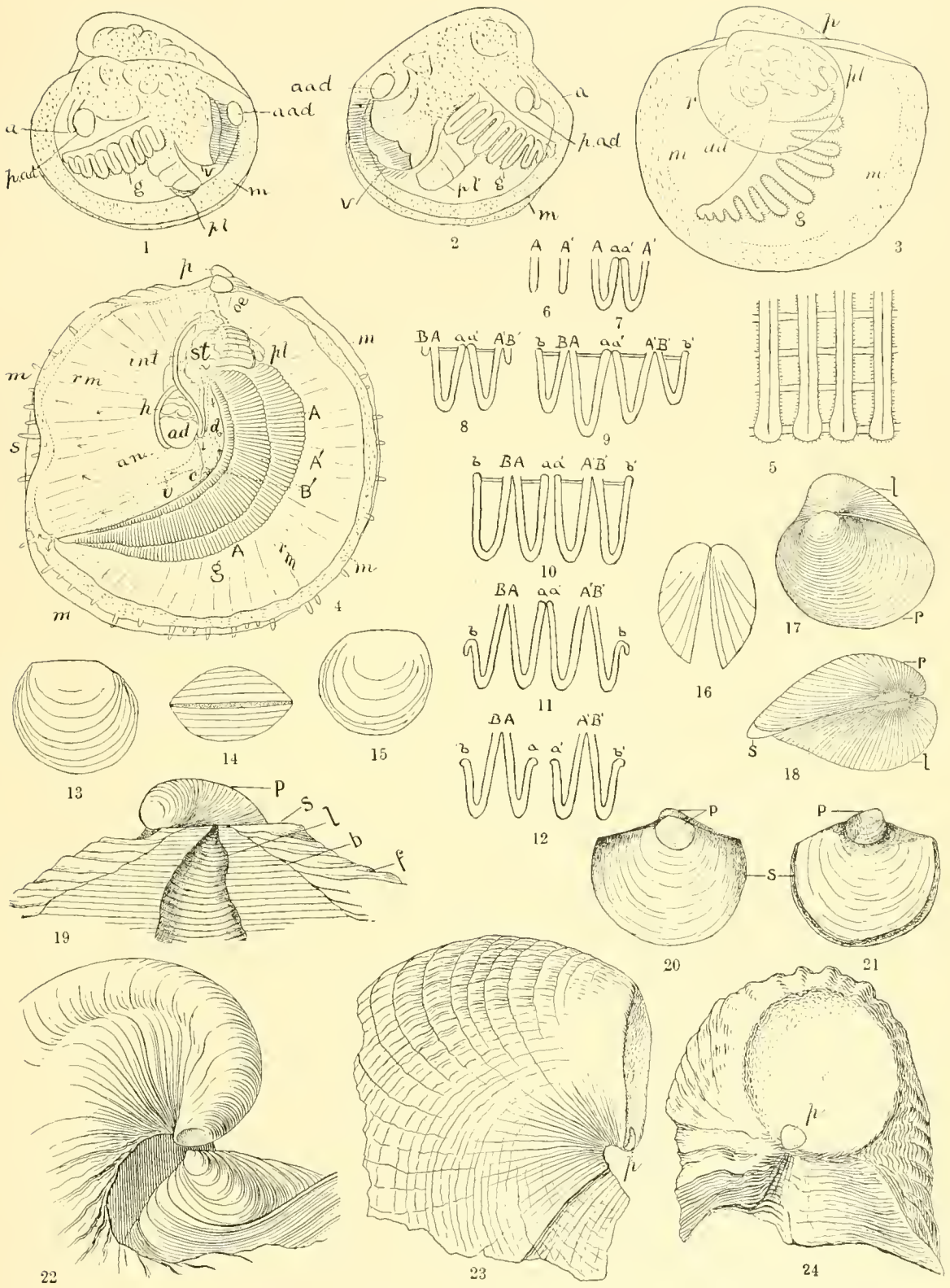
414 429 CICADINA.

Kamtschatka
Aland I.
Shumshu I.
Paramushir I.
Shirinki I.
Onekotan I.
Kharim-kotan I.
Ekarma I.
Shiash-kotan I.
Matua I.
Rashua I.
Ketoy I.
Shimushir I.
Broughton or Milkan-rgura I.
Chirpoi Brothers
Urup I.
Urup or Etorofu Str.
Etorofu or Iturup I.
Kunashiri I.
Shikotan I.
Yezo I.
Sapporo
Hakodate
Rebunshiri I.
Rishiri I.
La Perouse Strait
Soya
Sagalin I.
Manchuria
Sea of Okhotsk
Kurile Islands
Erimo
A
Sketch Map
of
the Kurile Islands
with a portion
of Yezo and Saghalin
(Based principally on the British
Admiralty Chart of 1886).

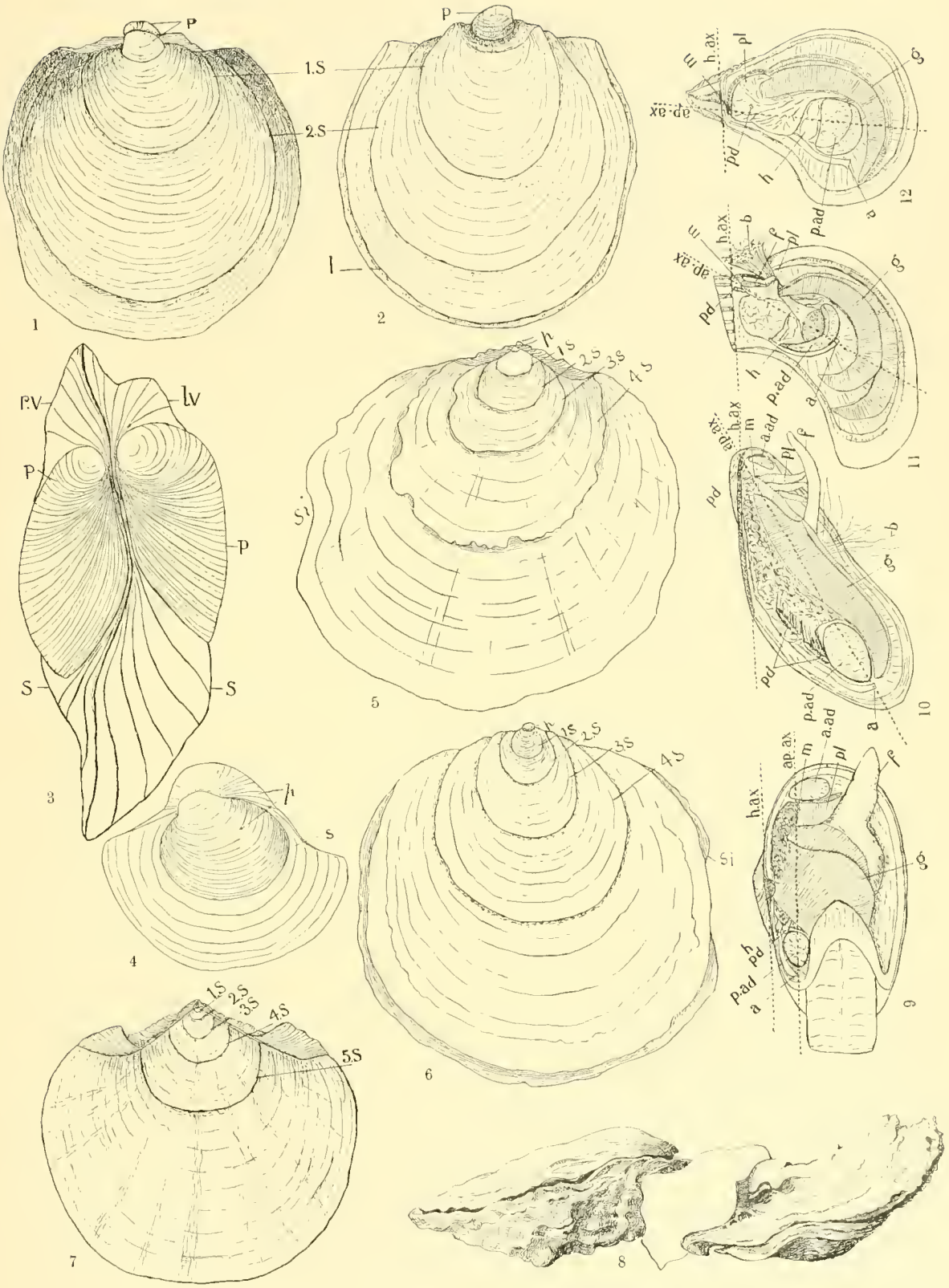


ENGRAVERS & PRINTERS, BOSTON

JACKSON PHYLOGENY OF THE PELECYPODA.

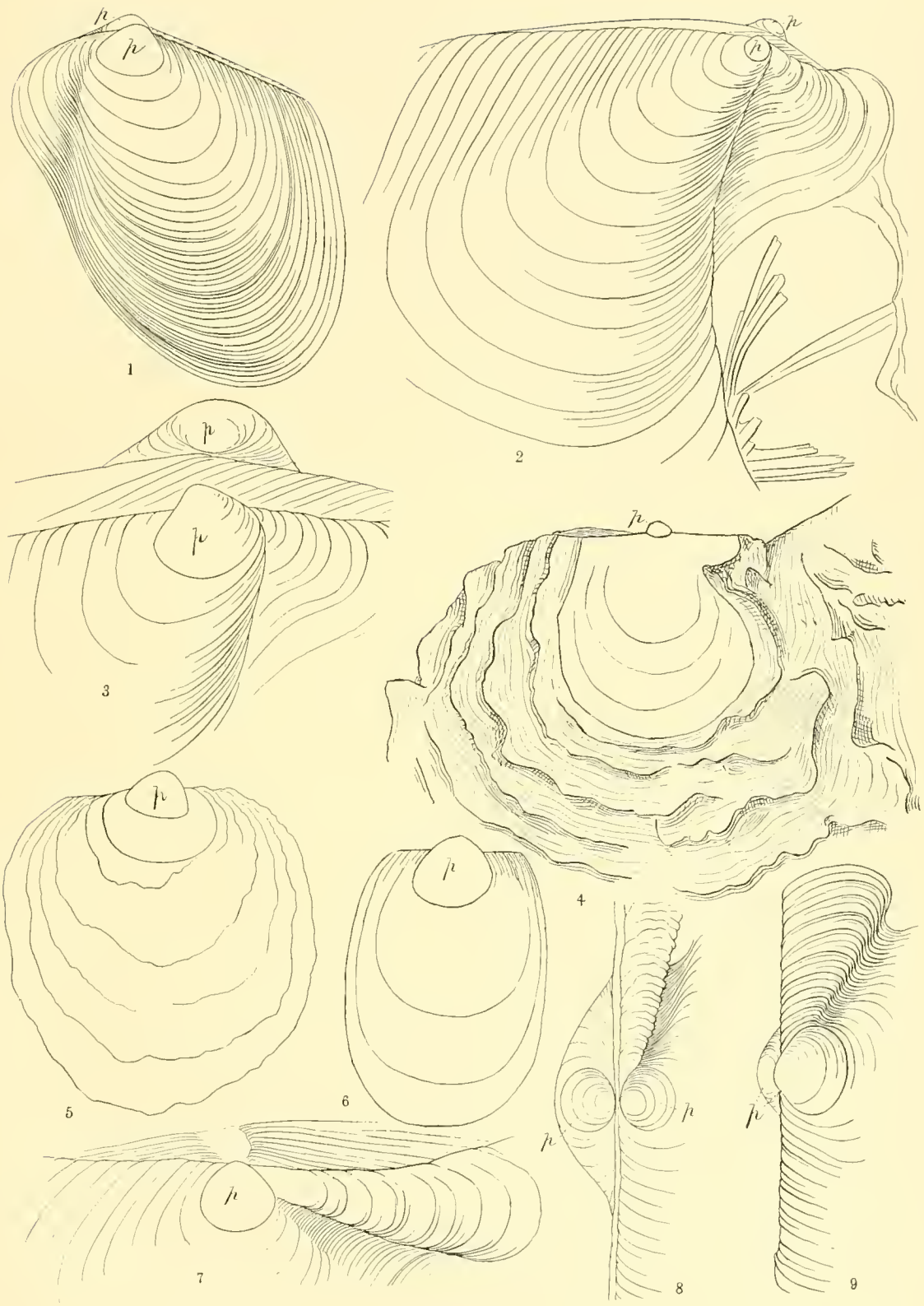


LUX CO., ENGRAVERS & PRINTERS, BOSTON

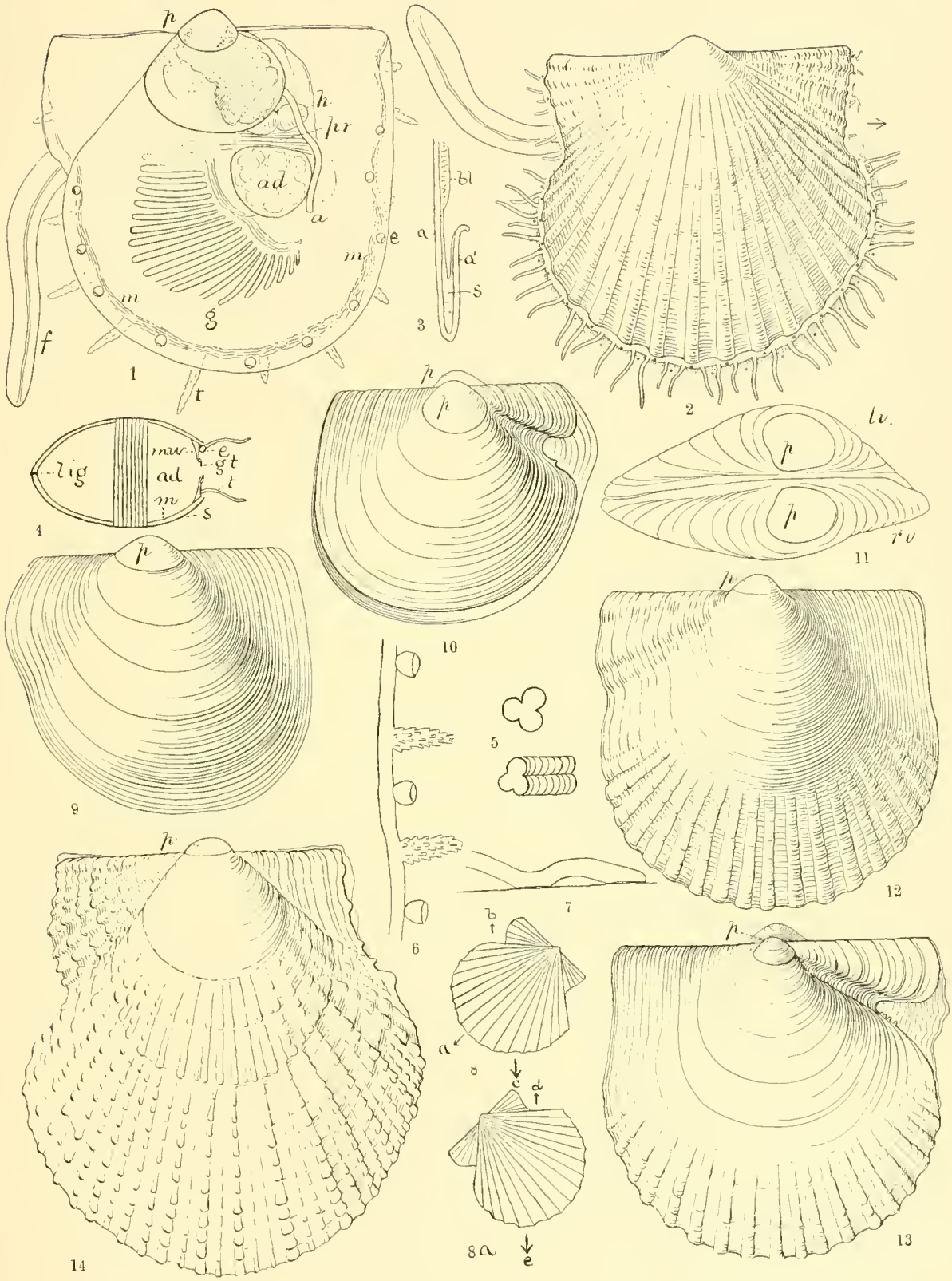


LUX CO., ENGRAVERS & PRINTERS, BOSTON.

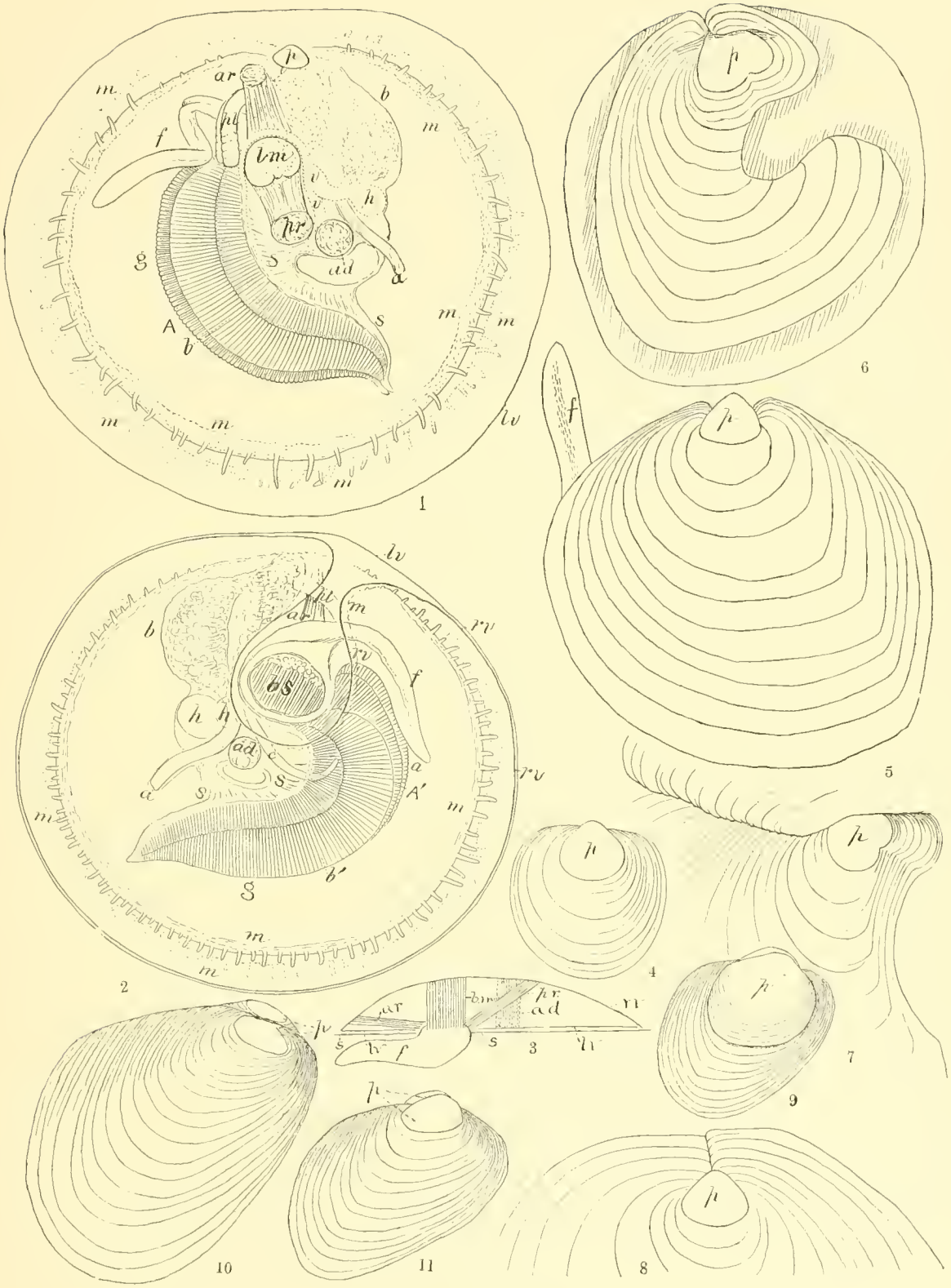
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
ad
l



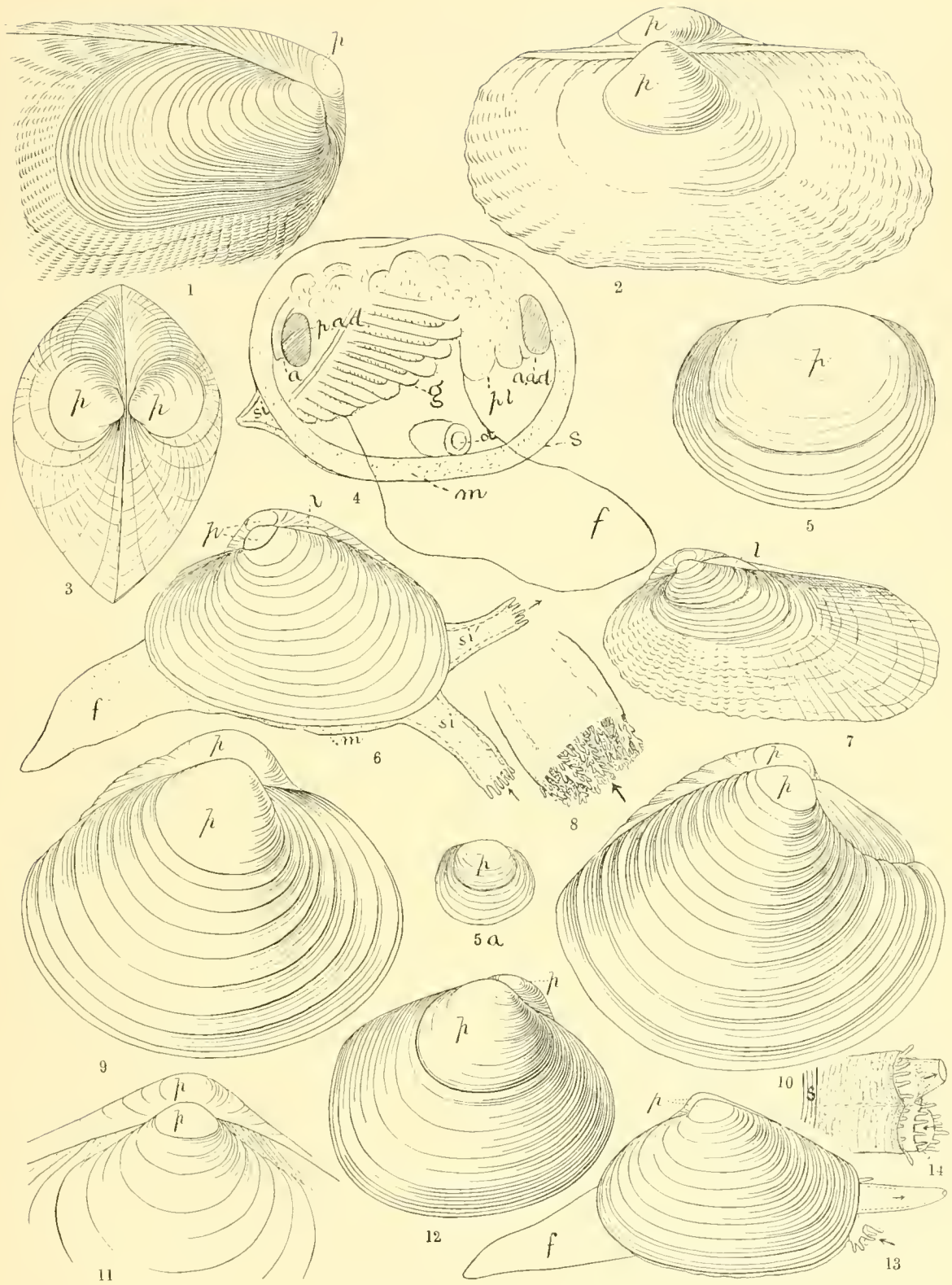
LOX CO., ENGRAVERS & PRINTERS, BOSTON.



LUX CO., ENGRAVERS & PRINTERS, BOSTON.



ENGRAVERS & PRINTERS, BOSTON



LUX CO., ENGRAVERS & PRINTERS, BOSTON

2

4

5

6

7

1.

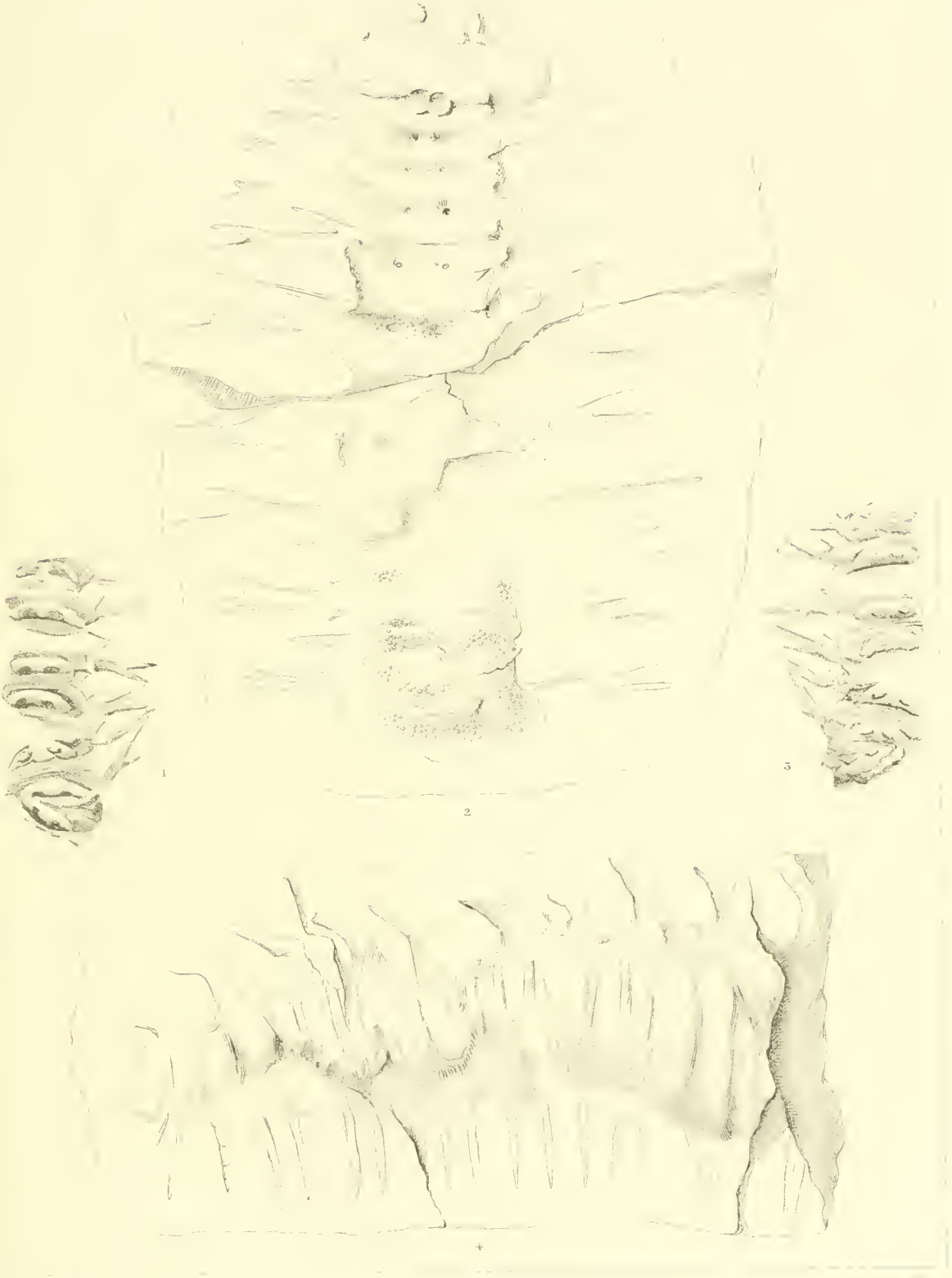
2.

3.

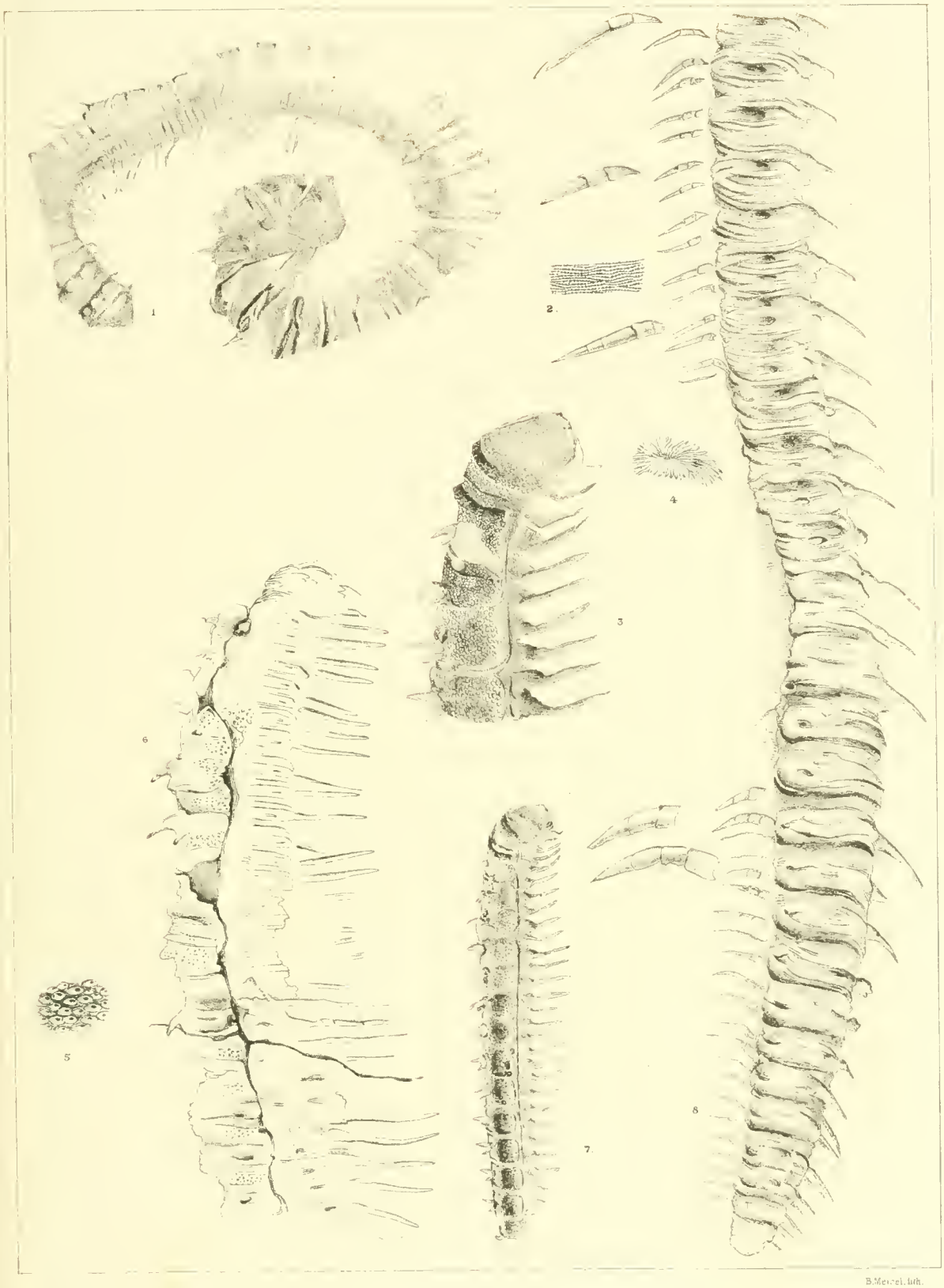
4.

5.

6.



SCUDDER ON CARBONIFEROUS MYRIAPODA



B. Mercer, lith.

SCUDDER ON CARBONIFEROUS MYRIAPODA

SCUDDER ON CARBONIFEROUS MYRIAPODA

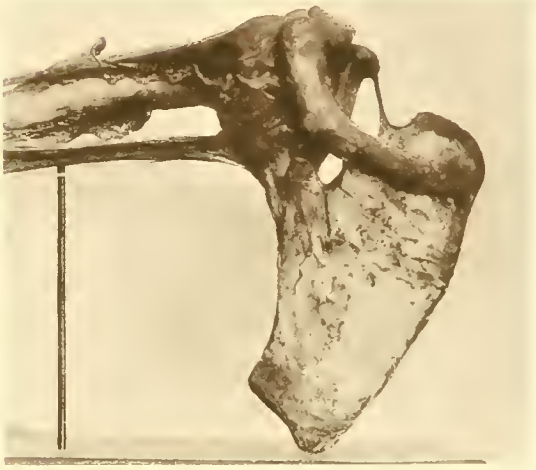
ARACHNIDA

1
3
4
5
6
8
9
10
11

SCUDDER ON TRIASSIC INSECTS OF COLORADO

1

2



3

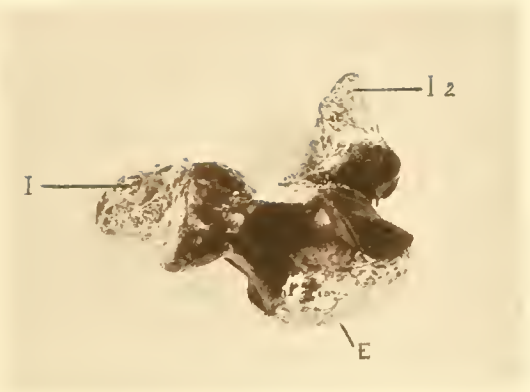
4

5

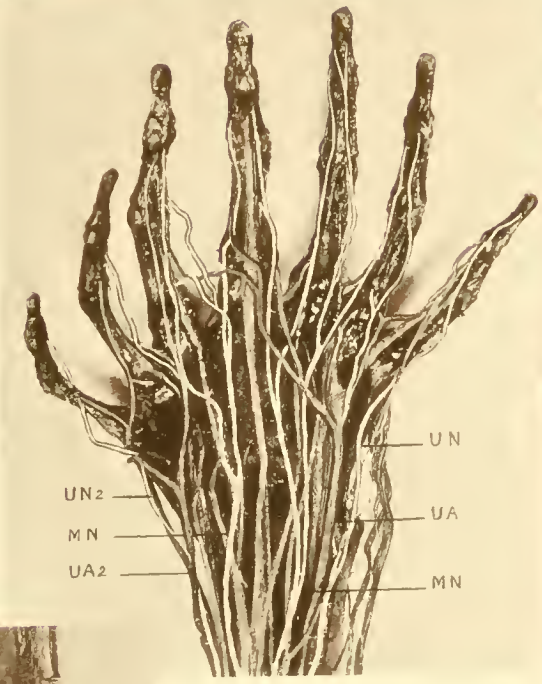
THE ART PUBLISHING CO., BOSTON, MASS.

DWIGHT, FUSION OF HANDS.

1

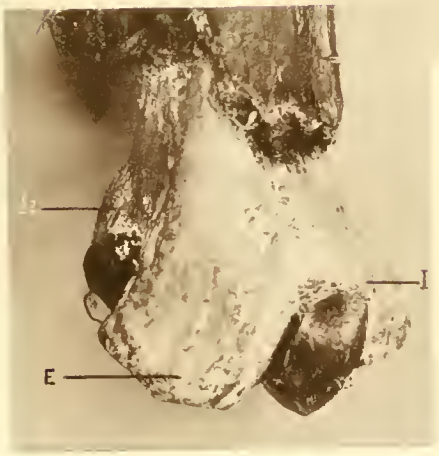


2



5

4



3

THE ART PUBLISHING CO., BOSTON, MASS.

DWIGHT, FUSION OF HANDS.

MEMOIRS

3488
Feb. 20. 1888

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER I.

THE SIGNIFICANCE OF BONE STRUCTURE.

By THOMAS DWIGHT, M. D.
Parkman Professor of Anatomy at Harvard University.

BOSTON:
PUBLISHED BY THE SOCIETY.
October, 1886.

3488
Feb. 20. 1888

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER II.

THE DEVELOPMENT OF THE OSTRICH FERN,

By DOUGLAS HOUGHTON CAMPBELL, Ph.D.

BOSTON:
PUBLISHED BY THE SOCIETY.
April, 1887.

MEMOIRS

3488
Feb 20, 1888

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER III.

THE INTRODUCTION AND SPREAD OF PIERIS RAPAE IN NORTH AMERICA, 1860-1885.

By SAMUEL H. SCUDDER.

BOSTON:
PUBLISHED BY THE SOCIETY.
SEPTEMBER, 1887.

3488
L. 20. 1888.

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER IV.

NORTH AMERICAN GERANIACEAE.

By WILLIAM TRELEASE.

BOSTON:
PUBLISHED BY THE SOCIETY.
JANUARY, 1888.

3488
May 22. 1888.

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER V.

THE TACONIC OF GEORGIA AND THE REPORT ON THE GEOLOGY OF VERMONT.

PLATE 13.

By JULES MARCOU.

BOSTON:
PUBLISHED BY THE SOCIETY.
March, 1888.

3488
May 22. 1888.

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER VI.

THE ENTOMOPHTHOREAE OF THE UNITED STATES.

By ROLAND THAXTER.

BOSTON:
PUBLISHED BY THE SOCIETY.
APRIL, 1888.

3488.

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER VII.

THE FLORA OF THE KURILE ISLANDS.

By K. MIYABE.

BOSTON:
PUBLISHED BY THE SOCIETY.
FEBRUARY, 1890.

3488.

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER VIII.

PHYLOGENY OF THE PELECYPODA,

THE AVICULIDÆ AND THEIR ALLIES.

PLATES XXIII—XXX.

By ROBERT TRACY JACKSON, S. D.

BOSTON:
PUBLISHED BY THE SOCIETY.
JULY, 1890.

3488.

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER IX.

NEW TYPES OF COCKROACHES FROM THE CARBONIFEROUS DEPOSITS OF THE UNITED STATES.

NEW CARBONIFEROUS MYRIAPODA FROM ILLINOIS.

ILLUSTRATIONS OF THE CARBONIFEROUS ARACHNIDA OF NORTH AMERICA, OF THE ORDERS ANTHRACOMARTI AND PEDIPALPI.

THE INSECTS OF THE TRIASSIC BEDS AT FAIRPLAY, COLORADO.

WITH PLATES XXXI-XLIII.

By SAMUEL H. SCUDDER.

BOSTON:

PUBLISHED BY THE SOCIETY.

SEPTEMBER, 1890.

3488

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER X.

FUSION OF HANDS.

WITH PLATES XLIII—XLIV.

By THOMAS DWIGHT, M.D., LL.D.

Parkman Professor of Anatomy at Harvard University.

BOSTON:

PUBLISHED BY THE SOCIETY.

AUGUST, 1892.

3488
NOV. 11. 1893

MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY;

VOLUME IV, NUMBER XI.

A BIBLIOGRAPHY OF VERTEBRATE EMBRYOLOGY.

By CHARLES SEDGWICK MINOT.

BOSTON:

PUBLISHED BY THE SOCIETY.

October, 1893.

PUBLICATIONS OF THE BOSTON SOCIETY OF NATURAL HISTORY.

PROCEEDINGS. 8vo.

Vol. XXV now issuing, $3.00 to members; $4.00 to the public. Vols. III, VII, VIII, XIV–XXIV per volume, bound in cloth $3.50 to members; $4.50 to the public.
Other volumes sold only in sets. Prices for complete sets on application.
Many of the articles printed in the Proceedings can be supplied separately.

JOURNAL. 8vo.

Series complete, vols. I–VII, $50.00. Vols. I, II, VI, VII per volume, $7.00.
Many of the articles printed in the Journal can be supplied in signatures.

MEMOIRS. 4to. A new Series of the Journal.

Vol. IV now issuing, $14.00 to members, $16.00 to the public. Subscriptions received per quarter volume.
Vols. I–IV each $14.00 to members, $16.00 to the public.

ANNIVERSARY VOLUME.

One volume 4to, 635 pages, 9 portraits, and 31 plates. Contains a history of the Society and a series of scientific memoirs. $15.00. The history of the Society, separately 250 pages, with portraits, etc. $5.00.

OCCASIONAL PAPERS. 8vo.

I. The Entomological Correspondence of Dr. T. W. Harris. Edited by S. H. Scudder. 375 pp. Portrait and 4 plates. 1869. Cloth, $1.50.

II. The Spiders of the United States. By N. M. Hentz. Edited by Edward Burgess, with Notes by James H. Emerton. 171 pp., 21 plates. 1875. Cloth, $3.50; Paper, $3.00.

III. The Geology of Massachusetts. By W. O. Crosby. 286 pp. Colored map and 5 plates. 1880. Cloth, $3.50; Paper, $3.00.

SEPARATE ARTICLES, EXTRACTED FROM THE QUARTO SERIES.

Ayres, Howard. Embryology of Oecanthus and Teleas. 1884, 56 pp., 8 plates. $2.50.

Brigham, W. T. Volcanic manifestations in New England. 1871, 28 pp. .50 cts.

Brooks, W. K. Development of Loligo pealii. 1880, 22, pp., 3 plates. $1.00.

Life history of Hydromedusae. 1886, 72 pp., 8 plates. $3.00.

Burgess, Edward. Anatomy of the milk-weed butterfly. 1880, 16 pp., 2 plates. $1.00.

Campbell, D. H. Development of the Ostrich fern. 1887, 36 pp., 4 plates. $1.50.

Carr, Lucien. Crania of New England Indians. 1880, 10 pp., 2 plates. .50 cts.

Clarke, S. F. Development of a double-headed vertebrate. 1880, 6 pp., 1 plate. .50 cts.

New hydroids from Chesapeake Bay. 1882, 8 pp., 3 plates. .75 cts.

Cones, Elliot and Wyman, Jeffries. Osteology and myology of Didelphys virginiana. With notes on the brain. 1872, 114 pp. $2.50.

Dwight, Thomas. Description of Balaenoptera musculus. 1872. 28 pp., 2 plates. $1.50.

The significance of bone structure. 1886, 15 pp., 3 plates. $1.25.

Fusion of hands. 1892, 14 pp., 2 plates.

Farlow, W. G. Gymnosporangia of the United States. 1880, 38 pp., 2 plates. $1.50.

Hinckley, Miss M. H. Notes on the peeping frog. 1884, 8 pp., 1 plate. .75 cts.

Hyatt, Alpheus. Revision of North American Poriferae. Part I. 1875, 10 pp., 1 plate. .75 cts. Part II. 1877. 74 pp., 3 plates. $2.00.

Genesis of the Tertiary species of Planorbis at Steinheim. 1880, 114 pp., 9 plates. $3.00.

Jackson, R. T. Phylogeny of the Pelecypoda. 1890, 123 pp., 8 plates. $3.00.

James, William. The feeling of effort. 1880, 32 pp. $1.00.

Kingsley, J. S. and Conn, H. W. Embryology of teleosts. 1883, 30 pp., 3 plates. $1.75.

Lancaster, A. Note on volcanic manifestations in New England. 1874, 9 pp. .35 cts.

Lawrence, G. N. and Grayson, A. J. Birds of western Mexico. 1874, 50 pp. $1.25.

Lyman, Theodore. Structural feature found in deep-sea ophiurans. 1880, 12 pp., 2 plates. .50 cts.

Marcou, Jules. The Taconic of Georgia. 1888, 27 pp., 1 plate. $1.00.

Minot, C. S. Distomum crassicolle, with notes on the classification of worms. 1878, 20 pp., 1 plate. .75 cts.

Studies on the tongue of reptiles and birds. 1880, 20 pp., 1 plate. .75 cts.

Miyabe, Kingo. The flora of the Kurile Islands. 1890, 72 pp., 1 plate. $1.75.

Morse, E. S. Early stages of Terebratulina. 1871, 12 pp., 2 plates. $1.50.

Embryology of Terebratulina. 1873, 16 pp., 2 plates. $1.50.

On the identity of the ascending process of the astragalus in birds with the intermedium. 1880, 8 pp., 1 plate. .50 cts.

Osten-Sacken, C. R. Monographs of Tabanidae. Part I. 1875, 33 pp. .65 cts. Part II. 1876, 59 pp. $1.00. Supplement. 1878, 6 pp. .35 cts.

Packard, A. S. Development of Limulus polyphemus. 1872, 48 pp., 2 plates. $2.00.

Gynandromorphism in Lepidoptera. 1875, 4 pp., 1 plate. .75 cts.

The anatomy, histology, and embryology of Limulus polyphemus. 1880, 41 pp, 7 plates. $3.00.

Scudder, S. H. Fossil myriapods from Nova Scotia. 1873, 9 pp. .35 cts.

The species of Pamphila. 1874, 13 pp, 2 plates. $2.00.

Structure and transformations of Eumaeus atala. 1875, 7 pp., 1 plate. .75 cts.

Supplementary notes on fossil myriapods. 1878, 2 pp. .35 cts.

The early types of insects. 1879, 9 pp. .35 cts.

Paleozoic cockroaches. 1879, 112 pp., 5 plates. $3.00.

The Devonian insects of New Brunswick. 1880, 41 pp., 1 plate. .75 cts.

Carboniferous myriapods. 1882, 40 pp., 4 plates. $2.00.

Carboniferous hexapod insects of Great Britain. 1883, 22 pp., 1 plate. .75 cts.

New Carboniferous myriapods. Species of Mylacris. 1884, 25 pp., 2 plates. $1.25.

Affinities of paleozoic hexapods. Winged insects from a paleontological point of view. 1885, 40 pp., 4 plates. $2.00.

The oldest known insect larva. Trichiulus. Mesozoic cockroaches. 1886, 55 pp., 4 plates. $2.00.

Introduction and spread of Pieris rapae in North America, 1860–1885. 1887, 16 pp., 1 map. .50 cts.

New types of Carboniferous cockroaches. New Carboniferous Myriapoda from Illinois. Illustrations of Carboniferous Arachnida. The insects of the Triassic beds at Fairplay, Col. 1890, 72 pp., 12 plates. $3.25.

Shaler, N. S. Recent changes of level on the coast of Maine. 1874, 20 pp. 40 cts.

Antiquity of caverns and cavern life of the Ohio valley. 1875, 9 pp., 1 plate. 40 cts.

Classification of lavas. 1880, 15 pp. 50 cts.

Thaxter, Roland. The Entomophthoreae of the United States. 1888, 68 pp., 8 plates. $3.50.

Trelease, William. North American Geraniaceae. 1888, 34 pp., 4 plates. $1.25.

Address Secretary Boston Society Natural History, Boston, Mass., U.S.A.

3 2044 072 225 980

Date Due

APR 07 '78

JUL 20